8-1-2011

Drowning Deaths in the Nearshore Marine Waters of the Island of Kauai, Hawaii 1970-2009

Charles Troy Blay
TEOK Investigations, teok@aloha.net

Follow this and additional works at: <https://scholarworks.bgsu.edu/ijare>

How does access to this work benefit you? Let us know!

Recommended Citation

Blay, Charles Troy (2011) "Drowning Deaths in the Nearshore Marine Waters of the Island of Kauai, Hawaii 1970-2009," *International Journal of Aquatic Research and Education*: Vol. 5: No. 3, Article 7.

DOI: <https://doi.org/10.25035/ijare.05.03.07>

Available at: <https://scholarworks.bgsu.edu/ijare/vol5/iss3/7>

This Research Article is brought to you for free and open access by the Journals at ScholarWorks@BGSU. It has been accepted for inclusion in International Journal of Aquatic Research and Education by an authorized editor of ScholarWorks@BGSU.

Drowning Deaths in the Nearshore Marine Waters of Kauai, Hawaii 1970-2009

Charles Troy Blay

Drowning is the number one cause of unintentional injury death on the Hawaiian Island of Kauai. Steep submarine slopes, large waves, and variable coastlines combine to create hazardous conditions year round. Most victims (3/4) have been visitors (avg. age 46.2 years; 85% male), dying at more than 40 coastal localities. From 1970 to 2009, 300 people died at the island's coastline, the death rate increasing from 5.5/yr (1970-79) to 10.1/yr (2000-09). Paradoxically, the number of lifeguards increased from a handful at two 1970s stations to 45 at 10 stations by 2009. Kauai County provides lifeguards; the State of Hawaii emphasizes liability protection with an abundance of relatively uninformative warning signs. The tourism industry provides little direct information as to the hazardous nature of the alluring coastline. A paradigm shift in water safety/drowning prevention is proposed emphasizing informative site-specific and hazard-specific signage at both the many unguarded and guarded hazardous localities.

Death by drowning in the nearshore marine waters of the Island of Kauai, Hawaii, is the leading cause of accidental death, exceeding even the island's automobile accident fatalities. In 2008 a record breaking number of drowning deaths (16) occurred at Kauai's coastline. The following year (2009), 10 more drowning fatalities occurred, matching the average for the decade 2000-2009 as well as the highest number for any ten-year period on record. During the 40-year period 1970-2009 investigated in this study, a total of 300 people drowned to death in the nearshore marine waters of the island, an average of 7.5 per year. Of greater significance has been the observed steady increase in the annual drowning death rate from 5.5 per year during the decade 1970-79 to 10.1 per year during the first decade of the new millennium, 2000-09. The considerable increase in drowning deaths was realized despite an increase in the number of water safety personnel (lifeguards), from just a handful in the 1970s to nearly 50 water safety officers in 2009. During the same time period, coastal lifeguard stations increased from two to ten, along with substantial enhancements in the type and abundance of lifesaving equipment such as personal watercraft and communication devices. The purpose of this investigation has been to examine in detail this alarming paradox. The study has been carried out implementing principally the point of view of an ocean scientist involved for over three decades in the examination of the dynamic zone of interaction between Kauai's shore and the North Pacific Ocean.

The author is with TEOK Investigations in Poipu, Kauai, Hawaii.

Kauai's water safety situation is unique and must be addressed as such, beginning with the core question: What makes water safety and drowning prevention on Kauai different from other localities? The island's North Pacific geographic setting, 20 degrees North latitude and nearly 4000 km from North America, places it in the middle of the planet's largest ocean (Figure 1). Large waves approach the island's steep shorelines from one side or the other year round, generating rough water, strong currents, and other conditions potentially hazardous to anyone in the island's nearshore marine setting. Kauai's perimeter, about half of which is rimmed by sandy beaches, varies considerably in terms of topographic/oceanographic character, resulting in wide variation in the nature of the water hazards from one locality to another. More than 50 of the island's attractive beaches and commonly visited rocky shoreline areas are accessible with relative ease, while lifeguard stations staffed with capable, well-equipped lifesavers are present at only 10 coastal stations. Kauai's pleasant tropical setting makes it a prime tourist destination, attracting a million or more visitors each year. Many, if not most, tourists lack knowledge regarding the hazardousness of its nearshore marine setting. Emphasizing such overall uniqueness, a paradigm shift in thinking with respect to nearshore marine water safety is proposed. The overall approach to water safety on Kauai begs revisiting.

Drowning is "the process of experiencing respiratory impairment from submersion/immersion in liquid" (van Beeck, Branche, Szpilman, Modell, & Bierens,

Figure 1 — Location of the Hawaiian Islands isolated in the middle of the North Pacific Ocean. Note the large area of the vast ocean south of Hawaii compared with that north of the islands.

2005). Drowning outcomes are classified as death, morbidity, or no morbidity, the latter two comprising the general category of “non-fatal drowning.” In most situations, nonfatal drowning incidents, also referred to informally as “near drownings,” are difficult to document. Drowning incidents that result in death provide the most reliable and consistent data. This study relies principally on drowning deaths, commonly referred to informally as “drownings.” However, for every drowning death on Kauai, numerous nonfatal drownings and aquatic injuries have surely occurred, perhaps similar to the findings of Moran (2010).

The profile of drowning victims on the island of Kauai differs markedly from averages for the rest of the U.S. and the world; see for comparison the World Health Organization Factsheet on Drowning (2007) and Drowning Facts and Figures from the U.S. Lifesaving Association (2009). Of the 300, nearshore marine drowning deaths for the 40 years covered in this study (1970–2009), males comprise 85% of the victims. The average age of all victims is 45.5 years; less than 5% have been under 20 years in age. Perhaps not surprising in such a tourist destination, nearly 75% of the victims have been visitors. To reverse the disturbing trend of increasing drowning deaths at the island’s coastline, a paradigm shift in approaches to water safety/drowning prevention is proposed that emphasizes more effective transfer of information by all entities engaged in water safety to visitors and residents alike. Proposed is the placement of prominent, informative site-specific and hazard-specific signs at points of contact for as many shoreline localities as possible, especially the many that lack the staffing of lifeguards and are well known for their numbers of drowning deaths.

Method

Sample

Even on a local scale, precise data on drowning deaths can be difficult to obtain. Data must be compiled from a number of sources and carefully crosschecked. Data compilation and information gathering in this investigation have been ongoing since the early 1980s. The bulk of the information procured on the 1970–2008 Kauai drowning deaths represents a tabulation of data from police reports, along with information gleaned from newspaper articles, mainly those in *The Garden Island* published daily on Kauai, and the *Honolulu Advertiser* published daily in Honolulu on the island of Oahu. Officials of the Records Section of the Kauai Police Department provided valuable comprehensive data spread sheets listing 1970–2009 drowning death case information compiled from police reports. Information on 1984–2008 Kauai drownings was compared with data from epidemiologist Dan Galanis (personal communication, 2009) of the Hawaii Department of Health in Honolulu, verifying the data as well as providing for minor modifications to the database. Newspaper articles reporting on nearly 90% of the drowning incidents were useful in expanding on many aspects surrounding each drowning incident.

Procedures

Since the early 1980s, the author has compiled information on the geologic and oceanographic character of Kauai’s shoreline (see Blay & Siemers, 2004), which strongly influences the variability of waves and currents at each specific locality.

Wave height data analyzed for the years 2004–2008 were obtained from the National Climatic Data Center (NCDC) in Asheville, North Carolina. Meteorological observations and data from ocean buoys north and south of Hawaii’s main high islands provided for the daily wave height estimates surrounding the main high Hawaiian Islands. Surf forecasts, principally those of Pat Caldwell of the National Weather Service in Honolulu (see Caldwell, 2005), have been issued since the late 1980s as a range of trough-to-crest heights explicitly for each the north-, east-, south-, and east-facing shores of the islands. Wave heights, in feet, are reported in ranges such as from 2 to 4 ft or 25–30 ft. The plots in Figures 6 through 8 were based on average daily forecasted wave heights over a full year. Two levels of data smoothing are displayed for each plot to illustrate wave height variation over a year’s period of time. Information on the history of water safety activities on Kauai was compiled from the review of nearly 500 newspaper articles, 1972–2009, from principally *The Garden Island* and secondarily the *Honolulu Advertiser*.

The Setting

The main islands of Hawaii are well known globally as a paradisiacal tourist destination year round. During Hawaii’s summer months of May–September daily temperatures over a 24 hr period at sea level average in the mid to high 70s; the winter months of October–April see that average drop less than 9 °F to the low 70s (Jurvik & Jurvik, 1998). Clear aquamarine ocean waters that surround the islands retain similar temperatures. Beautiful, seemingly endless white to buff colored sandy beaches circle the islands in abundance. One of the first things a visitor to Hawaii may understandably wish to do is get to the beach and jump in the warm inviting water. A recent visitor survey by the Kauai Visitors Bureau (KVB) indicated that, following “scenery/natural beauty,” “beach, sunbathing and relaxation” is a tourist’s first interest when considering visiting Kauai (Sue Kanoho, Director of KVB, personal communication, 2008).

Tourism is at the core of Hawaii’s economy, and is heavily promoted worldwide by numerous State and County agencies as well as by independent businesses of all kinds. For trip planning, a 2008 KVB survey indicated that over 50% of the island’s visitors relied mainly on information provided by websites such as that of KVB, travel and guide books, and travel reservation websites such as Expedia or Travelocity (Sue Kanoho, personal communication, 2008). Unfortunately, relatively little information has been disseminated to visitors by these sources on the hazards of the nearshore ocean environment. The vast majority of the visitors to Kauai, commonly now about a million annually, likely arrive unaware that death by drowning is the island’s number one cause of accidental death. In most years, more than twice as many people have died of drowning in the nearshore marine environment than from traffic accidents (Records Section, Kauai Police Department, yearly reports available upon request). Without doubt Kauai’s location in the middle of the big wave-generating North Pacific Ocean, its beauty and attractive climate, and the details of the island’s physiography, especially that of its extensive easily-accessible but highly-variable shoreline, all contribute to the generation of the high numbers of drowning deaths. In addition, visitor ignorance (i.e., lack of knowledge) of the hazardous conditions that exist in the nearshore marine waters of the island has contributed significantly to the unacceptably high number of drowning fatalities.

Location and Physiography of Hawaii's Volcanic Mountain-Islands

Stretching across the middle of the North Pacific Ocean for over 2,500 km (Figures 1 & 2), the more than 130 islands of the Hawaiian Archipelago, from the Big Island of Hawaii to the atolls of Midway and Kure, comprise the State of Hawaii and represent the planet's most isolated occupied major land mass. Compared with the other states of the United States, Hawaii, with a total island land area of only 16,636 square kilometers, is 47th in size. Only the states of Rhode Island, Connecticut, and Delaware are smaller. The eight high islands that span a distance of 550 km at the southeastern end of the archipelago, from the Big Island of Hawaii to the islands of Kauai and Niihau, comprise over 99% of the land area of the state of Hawaii. The closest major land mass is North America at a distance of about 3,900 km from the main high islands. Japan is 6,100 km to the northwest. Midway Atoll, at the northwestern end of the Hawaiian Archipelago, lies approximately halfway between North America and Asia. The islands of Hawaii lie near the middle of the largest body of water on Earth.

Kauai, like all the islands of Hawaii, is merely the tip top of a massive, broad shield volcano with its base spread out across the floor of the Pacific Basin at a depth of nearly 5,000 m below sea level (Figure 2). Very little of the mass of Hawaii's volcanic mountains extends above sea level to form the state's well-known islands. Collectively, from Hawaii Island to Kure Atoll, only about 2.5% of the mass of the nearly 110 volcanic mountains that comprise the chain is above sea level (Barger & Jackson, 1974). The giant shield volcanic mountains and associated island tops, formed in the middle of the ocean as the Pacific Tectonic Plate (encompassing

Figure 2 — Artistic representation of the Hawaiian Archipelago, illustrating the occurrence of islands as the tops of giant shield volcanic mountains. Relief and mountain slope steepness are exaggerated. Surrounding ocean depths extend to nearly 5,500 meters. Less than 2.5% of Hawaii's volcanic mountain-island complex, from the island of Hawaii to Kure Atoll, is above sea level. The island of Kauai is only about 5% of the above sea level part of its volcanic mountain-island complex. Very little shallow shelf area exists around the islands to dampen approaching ocean waves.

most of the Pacific Ocean seafloor), have moved northwestward at rate of about 8.5 cm per year, across the Hawaiian Magmatic Hot Spot (for example, see Clague, 1996). A portion of the geologically youngest island, Hawaii Island, is directly above the hot spot and still growing. Kauai was located above that hot spot 5–6 million years ago and has since moved along on the tectonic plate 550 km to the northwest, becoming an extinct shield volcanic mountain. Over that time period, Kauai's mountain-island edifice has subsided (sunk) at least 1,000 m, owing to its mass. Today the highest point on the extensively eroded island is at an elevation of 1,598 m. Less than 5% of Kauai's volcanic mountain-island mass is above sea level. As the volcano subsided there was little time for ocean waves to cut a significant shelf offshore of the shrinking island perimeter. As a result, water depths increase rapidly offshore around the steep undersea mountainsides. Around most of the island, even portions with fringing reef platforms, water depth increases to 20 m within less than a kilometer from the shoreline and to 100 m within less than 2 km (Figure 3). Because of the steepness of the nearshore bathymetry, the powerful deep ocean waves that approach the island throughout the year suffer minimal loss of energy due to bottom friction as waves transform from deep to intermediate depths. Shoaling waves undergo substantial height amplification before expending

Figure 3 — Bathymetry of the sea floor surrounding the Island of Kauai. Contours, originally recorded as fathoms (i.e., multiples of 6 feet), represent approximate depths of 20, 40, 100, 200 and 2000 meters. The great water depths immediately surrounding the island have little influence on diminishing the magnitude and intensity of approaching ocean waves. (Map modified from 1:250,000 scale US Geological Survey and Coast and Geodetic Survey maps of Kauai, 1970).

their energy quickly and sometimes violently on the shoreline (Caldwell & Aucan, 2007). Some of the planet's biggest waves smash directly into the island's shorelines, especially those on the north shore during Hawaii's ocean winter months.

Kauai's Shoreline—The Beaches

Kauai's beautiful shoreline is highly variable, a key aspect of this investigation. The near circular, 40–51 km-diameter island has an area of 1,430 square kilometers (Jurvik & Jurvik, 1998). Nearly half (47%) of the island's 178-km perimeter is composed of sandy beach; the rest is mainly rocky and rugged (Blay & Siemers, 2004). More than 50 distinct beaches, most easily accessible, have been delineated (Figure 4). Almost all beaches are composed predominately of light-colored calcareous grains of skeletal material, mainly coralline algae and coral fragments, derived from nearshore marine reef settings. Most of Kauai's beaches are quite attractive and are visited throughout the year by many of the island's 65,000-plus residents as well as most of the visitors to the island, numbering nearly a million each year.

No two beaches on Kauai are the same with respect to most parameters, including geometry, sand type, nearshore waves and currents, and potential hazards for swimming, snorkeling, and other ocean use activities. These variations constitute a primary aspect of the uniqueness of Kauai's water safety situation.

Figure 4 — Shaded relief map of Kauai showing locations of the island's major beaches. Nearly 50% of the island's approximately 178 km perimeter is sandy beach, most of which is easily accessible.

Pocket Beaches. The majority of the island's beaches fall into the category of distinct "pocket beaches" that occupy small to moderate bay-like indentations in Kauai's irregular shoreline. Most of the beaches along the island's southern, eastern, and northern coasts fall into this category; however, each specific pocket beach still displays characteristics that differentiate it from all other pocket beaches. Such bayhead type beaches commonly are only a few hundred meters long; some are much smaller. They are confined at each end by seaward-extending rocky headlands. Most occupy bays formed at the mouths of river valleys that were incised into the island's perimeter during lower sea level and then drowned by subsequent sea level rise. Over the past one to two million years, sea level has fluctuated by as much as 120 m every 100–125 thousand years in response to global cycles of glaciation. Approximately 18,000 years ago, sea level was 100–120 m lower. Rivers cut their valleys into the exposed coastal zones and carried sediment all the way to distant shoreline positions. As sea level rose to its present high stand level, the incised river valleys were flooded, creating the bay-like indentations in the shoreline we now see around most of the island. The bays have become traps for sediment, much of which accumulates at the bay head shoreline to create a sandy beach. Sand in these beach cells moves off and onshore, respectively, during high and low energy wave conditions (somewhat seasonal) resulting in variable beach width.

Strandline Beaches. Around the westernmost perimeter of the island, specifically the broad coastal area of the low-lying Mana Coastal Plain extending west of Waimea (Figures 3 & 4), sandy beaches extend continuously for over 25 km from the mouth of the Waimea River to where the whitish sand of Polihale Beach terminates up against the blackish lava rock cliffs of the Na Pali coast (see Figure 4). This complex represents the longest continuous strand of sandy beach in the entire state of Hawaii. Sand along this coast is moved easily along the shore by shore-parallel, longshore currents; however, it also moves onshore and offshore under the influence of variable wave conditions.

Na Pali Coast Beaches. Na Pali (literally "The Cliffs") extends for over 22.5 km along the northwestern perimeter of Kauai, from Kee Beach to Polihale Beach (Figure 4). Sheer lava rock sea cliffs are hundreds of meters high along this coast. The few major beaches that occur along this coast, namely Hanakapiai, Kalalau, Nualolo, and Milolii, are relatively isolated to remote. Hanakapiai Beach, one of the island's deadliest (29 drowning deaths since 1970), can be reached relatively easily by hiking a 3.2-km trail from Kee Beach. Kalalau Beach access requires a 17.5-km hike. Remote Nualolo and Milolii beaches are accessible by boat.

Reef Platforms. Many beaches, especially those along the northeastern and northern coastal areas of Kauai, are associated directly with prominent fringing reef platforms (Figure 4; black on the diagram denotes reef). Since they are constructed by photophilic plants and animals that must live within the shallow photic zone of the ocean, and since water depths increase rapidly offshore on Hawaii's mountain top islands, the reefs develop right at the shoreline. Barrier reefs do not develop around these islands since the water is just too deep even a short distance offshore. Almost all of the reefs of Kauai are characterized by shallow platforms that extend directly from the shoreline, commonly a sandy beach, offshore for as much as a half of a kilometer. At the very shallow (less than a meter deep) seaward edge of the platform the reef front then drops steeply down slope. Very little reef development occurs

below water depths of 30 or even 15 meters. The main hazard at beaches fronted by a reef platform involves permanent, deeply incised reef channels, sometimes referred to as “tidal channels,” that extend from the beach all the way to the shallow seaward front of the reef. Extremely strong, seaward-directed currents develop in such channels as water washed over the reef by waves returns to the open ocean. Such channelized currents are especially strong when the tide is dropping and much of the high-tide water on the reef platform also is funneled off the surface through the reef channels. Almost all of the drowning deaths at beaches associated with reef platforms involve people being suddenly pulled out to sea through reef channels.

The Waves

Without question, ocean waves and wave-generated currents are directly responsible for the majority of drowning deaths in Hawaii. They create the hazardous nearshore marine conditions in which people get in trouble and many drown (see Caldwell, 2005). Isolated near the middle of the Pacific Ocean, the islands of Hawaii feel the effects of the weather occurring throughout this vast ocean (Figure 5). Distant ocean storms generate wind waves that gather into ocean swell systems and then travel the entire breadth of the ocean basin. The only part of these storms that manifests

Figure 5 — Wind and wave systems that impact Kauai’s shorelines. Modified from Moberly and Chamberlain, 1964.

itself in Hawaii is the coastal surf generated by these ocean swells. Most of the large waves that impact the north shores of the islands in the North Pacific Ocean's winter months of October-April and the south shores in the ocean's summer months of May-September are the products of such seasonal events. Hawaii's summer south shore waves are mainly the product of winter storms occurring throughout the Pacific Ocean's vast southern hemisphere (see Figure 1).

Local weather conditions also affect Hawaii's coastlines. Persistent northeast trade winds, blowing 75–85% of the time (Figure 5), generate waves that impact eastern coasts throughout most of the year. In addition, relatively local winter storms, known locally as “Kona” systems, produce waves that approach from the west and southwest. In the ocean surrounding the Hawaiian Islands, a calm sea is rare.

The plots of forecast wave heights shown in Figures 6–8 illustrate the seasonally variable wave systems. Waves that approach the island's north and south

Figure 6 — Plots of average predicted daily wave heights for the four sides of Kauai for 2006. Two smoothing curves are shown for each plot. Only data points lying above the smoothing curves are shown. Note the high winter north shore and summer south shore waves. West side waves are merely smaller refracted north shore waves. Tradewind-generated east shore waves are irregular throughout the year.

shores throughout the year best display the dramatic seasonal contrast that so well defines the situation in Kauai and throughout the State of Hawaii. Figure 6 displays plots of the average daily predicted wave heights that approached all sides of the island throughout the calendar year 2006, a typical year. During the ocean's winter months, frequent North Pacific storms generate the wave systems that move south to smash into the island's north-facing shores. Owing to the island's proximity to North Pacific Ocean winter storms, the waves generated by such storms are some of Hawaii's largest, commonly reaching heights of greater than 7.5 m (see Vitousek & Fletcher, 2008). Traveling in groups ("sets") of five to seven swells each, winter wave systems approach rapidly, commonly within a few hours, build up quickly, and then die out over a few days.

Throughout the ocean's summer months, north shore waves are considerably smaller; however, swells generated by the then winter southern hemisphere storms approach the south shores of the Hawaiian Islands. In magnitude, the southern swell waves are much smaller, owing to the dampening of wave energy during long distance traveled, but the 1.5–3 m high wave events can produce rough water and very strong currents of all types that can be hazardous to swimmers. Waves systems from the south commonly build up gradually over a day or two, last for two or three days, and then die out gradually, reflecting their organization during the long distance of travel (see Bascom, 1980).

Waves approaching the west-facing shores are similar to those of the north, although clearly smaller, since they represent mainly a refractive, wrap-around extension of the north shore wave systems. East shore waves, generated mainly by persistent northeast trade winds, occur throughout the year. They are a messy mix of short period wind waves and longer period swells, all generated within a relatively short distance from the islands. Winter east shore waves are typically slightly larger owing to the combined refractive, wrap-around influence of north shore waves.

The largest north shore wave events occur through the months of November through March, as expected, but very few large wave events with wave heights greater than 1.5 m occur before October or after April. Figure 7 displays plots of north shore waves emphasizing the occurrence of winter waves over four consecutive years. The consistency is striking. Only a couple of "unseasonable" large wave events, in August 2004 and May 2008, are indicated. Hawaii's north shore is well known for its reputation of "big waves," but throughout the summer north shore waves are relatively small on all of the islands of the state.

South shore waves (Figure 8) are significantly different from those of the north. From year to year, most large south shore wave events, 1.5–3 m waves, are confined to summer months; however, unseasonable large wave events also are common, especially during the months of October, November, and December. Since the area of the Pacific Ocean to the south of Hawaii is so much larger than that to the north, wave-generating storm events can occur in so many more areas, such as Australia, New Zealand, the west coast of South America, and the general broad region of the Antarctic.

Figure 7 — Plots of average predicted wave heights for the north shore of Kauai for 2004–2008. Two smoothing curves are shown for each plot. Only data points lying above the smoothing curves are shown. Note the relative similarity of wave patterns from year to year with the winter months (Oct–Apr) well defined by high winter surf.

Figure 8 — Plots of average predicted daily wave heights for the south shore of Kauai for 2004–2007. Two smoothing curves are shown for each plot. Only data points lying above the smoothing curves are shown. Note the concentration of high wave events through mainly the summer months.

Kauai Shoreline Drowning Deaths 1970–2009

Death by drowning in the nearshore marine waters of Kauai is the main cause of accidental death on the island. Over the 40-year period, 1970–2009, a total of 392 drowning deaths were recorded on Kauai. More than three-fourths (300) were due to nonboating incidents occurring at the ocean shoreline. The others, not dealt with herein, occurred inland in rivers, lakes, swimming pools, and at private residences. Over the entire 40 years analyzed, the annual average of shoreline drowning deaths was 7.5. Since the year 2000, that average has exceeded 10 per year. Over the 20-year period 1990–2009, there were 176 shoreline-drowning deaths (nearly 9

per year) compared with 152 Kauai Island traffic fatalities (7.5 per year). Figures 9–15 display many of the aspects of the shoreline drowning deaths.

Drowning Locations

The island map display of Figure 9 illustrates the general location and seasonal aspect of drowning deaths on Kauai, 1970–2009. More than two-thirds of the drowning deaths at north coast beaches (Polihale to Kilauea) occurred during the ocean's seven winter months, October through April, when the surf is big and wave-generated currents are the strongest. Less than a third of the north shore deaths occurred during the ocean's five summer months. Hanakapi'ai, Lumahai, and the Haena area beaches have been some of the most dangerous. Polihale Beach on the west, another winter drowning beach, is grouped with the north shore beaches since the waves that wrap around the west side of the island are mainly those generated in the North Pacific. Drowning deaths at south coast beaches (Kekaha to Kipu Kai) have been distributed more evenly throughout the year. Although much smaller than the north shore winter surf, the south shore's summer waves are larger than the area's winter waves.

Since 1990 the number of drowning deaths at Poipu area beaches increased dramatically, due most likely to the area's increasing popularity, extreme ease of access, and hazardous wave dynamics. The numerous S.C.U.B.A.-related drowning deaths along the south coast have been due to the greater popularity of that sport in the area. Drowning deaths at east coast beaches (Larsen's to Kalapaki and Nawiliwili) have been evenly distributed throughout the year due in part to the year round presence of rough water and strong currents produced by the persistent trade winds. In addition, resorts are abundant in the Wailua-Kapaa area of the east coast, and most beaches there are very easily accessed. Few are guarded.

Factors Related to Increasing Drowning Trend

The cross-plot of Figure 10 displays the trend of increased drowning deaths throughout the study period from 1970 through 2009. On average, the number of drowning deaths per year has increased from less than six in the 1970s to 10 through the first decade of the new millennium, but the increase has not been a steady trend. Major dips in the annual number of drowning deaths occurred in the early 1980s, early 1990s, and just a couple of years into the new millennium. A probable explanation for the seemingly complex trend in drowning deaths since 1970 is provided by the cross-plot of visitors per year shown in Figure 11. Shortly after Hurricane Iwa (November 23, 1982) and Hurricane Iniki (September 11, 1992), the number of visitors dropped precipitously. Again, after the terrorist's attack on New York's Trade Center buildings (September 11, 2001) and the SARS pandemic scare in 2003, the number of visitors traveling to Hawaii also dropped. Every time there has been a sudden decrease in the number of island visitors, a similar drop in the number of nearshore marine drowning deaths has followed. The drop in the number of shoreline drownings from 16 in 2008 to 10 in 2009 may in fact reflect the decrease in visitors to the island as a result of the U.S. and global economic downturn beginning about that time. The data displayed in Figures 10 and 11 suggest a close correlation between the number of visitors to the island

Figure 9 — Map showing the distribution of drowning deaths on Kauai 1970–2009.

Figure 10 — Plot of annual ocean shoreline drowning deaths on Kauai 1970–2009. Drowning symbols represent data points.

Figure 11 — Plot of annual westbound visitors to Kauai 1970–2009. Westbound visitors are mostly from the mainland U.S., Canada, and Europe. Airplane symbols represent data points.

and number of shoreline drowning deaths. Such a relationship has persisted in spite of the continuously increasing number of lifeguards, lifeguard stations, and water safety equipment over the four decades since 1970, the details of which are reviewed in a later section of this paper on the history of water safety on Kauai.

Island-wide, the number of drowning deaths occurring at Kauai's shoreline has not varied much from month to month or from season to season (Figure 12), even though there are more drownings on the north coast in the winter and more summer drownings along the east and south coasts. Over the 40-year period of this case study, December, with its huge north shore waves, has been the month with the most drowning deaths (37). The early winter month of October has recorded 29 deaths; however, the three high-volume visitor summer months of August (32) and both July and September (27 each) have also been times of high drowning death numbers. Using a similar manner of analysis, the month of June, commonly a high-volume month for visitors to the island, has somewhat inexplicably had the fewest number of drowning deaths (15). Obviously, in addition to the time of the year, there are additional factors influencing these numbers.

Activities Related to Drowning

Most visitors to Kauai who have died by drowning in the nearshore areas were involved merely in swimming and/or snorkeling (Figure 13). Nearly 80% of visitor deaths (174 of 220) occurred during this activity compared with only one-third (26 of 80) for residents. In terms of absolute numbers, drowning deaths from S.C.U.B.A. diving and surfing are comparable for visitors and residents, but in terms of percentage, residents have been much more likely to die during these activities. Numerous residents (30%) have perished at the shoreline while fishing (pole and throw-net)

Figure 12 — Drowning deaths per month on Kauai, 1970–2009.

and opihi picking, activities not commonly engaged in by visitors. Opihi, a local culinary delicacy, are small limpets that cling to rocky surfaces mainly in intertidal zones. Many locals have been knocked down by waves and drowned within a few meters of the shore while scraping opihi off in such high-energy locations; very few visitors even know what they are. A rather telling indicator of the conditions at Kauai’s shoreline is the number of visitors (nearly 10%) who have been knocked down, dragged into the ocean, and perished while merely standing on a rock at the shoreline or walking along the beach or rocky shore.

Drowning Demographics

The average age of those who died by drowning on Kauai 1970–2009 is 45.5 years, with 64% being between 30 and 60 years of age (Figure 14). Visitors comprise 73.5% of those who have died by drowning, averaging 46.2 years in age; residents that died (26.5% of the total) averaged a relatively similar 43.8 years of age (Figure 15). Males represent 85% of the individuals who have died (Figure 15). Over the first 30 years (1970–99) the male:female drowning death ratio was 9:1; over the last ten years (2000–2009), however, that ratio dropped to slightly less than 8:1. It is the middle-aged male visitor, mostly from the continental United States, who has been the most common victim.

Statewide Drownings

Rather little data are available to compare the number of drowning deaths statewide in Hawaii, but what data are available indicate that the island of Kauai is not necessarily the most dangerous place in the state. Data for the seven-year period from 2001 to 2007 indicate that nearly four times as many people died by drowning on the island of Oahu than on Kauai (Dan Galanis, Hawaii Department of Health, personal communication, 2008). Most of the Oahu victims were classified

Activity	Visitors (n = 220)	Residents (n = 80)
Swimming - Snorkeling	174	26
S.C.U.B.A. Diving	9	8
Surfing	11	12
Shoreline Fishing	1	12
Opihi Picking		10
Walking / Standing	20	2
Miscellaneous	6	10

Figure 13 — Activities engaged in when drowned to death on Kauai, 1970–2009.

Figure 14 — Ages at death when drowning in the nearshore marine waters of Kauai, 1970–2009.

Figure 15 — Histograms of origin and sex of nearshore marine drowning death victims: Kauai, 1970–2009.

as residents; however, many of them were in the military and, like island visitors, not necessarily that familiar with local ocean conditions. Maui County (including the islands of Maui, Molokai, and Lanai) recorded slightly fewer drowning deaths than Kauai, also with most being visitors. The Big Island of Hawaii had a few more drowning deaths than Kauai and Maui; however, the majority were residents. The comparison of drowning deaths by island in Hawaii involves even more variables than those dealing with just one island. Such a comparison is of interest but somewhat beyond the scope of this paper.

Kauai's Variable Shoreline Situations

General Accessibility and Lifeguard Presence

The considerable variability of the hazardous ocean shoreline conditions that exist from one locality to the next around Kauai provides for a unique profile for water safety and drowning fatalities. Table 1 summarizes significant aspects of the 18 localities at which more than five drowning fatalities occurred during the 40-year span dealt with in this study. Of primary concern is that hazards existing at any specific shoreline setting not only differ from those of other localities but also vary considerably from season to season and frequently even from day to day. In addition, aspects such as popularity and ease of access, as well as the presence or absence of a lifeguard station, commonly are reflected in the number of drowning deaths that have occurred at specific locations. Expectedly, most drownings (68.5%) have occurred at beaches that are easily accessible, commonly a short walk from a parking lot. Data are limited for comparing the numbers of drowning deaths at guarded and unguarded beaches on Kauai, but in recent years (2003–2009), the vast majority (55/66; 83.3%) of drowning deaths on Kauai have occurred at unguarded beaches, some easily accessible, others remote. In comparison with the water safety situation on Oahu over the same six-year period, it is interesting to note that the majority (15/27; 55.6%) of drowning deaths on the more populous and more frequently visited island have occurred at beaches supervised and surveyed by lifeguards. Of course it must be emphasized that most beaches on Oahu are easily accessed and guarded and that the number of beach visitors to guarded beaches on Oahu far exceeds that of Kauai. From 2003 to 2008, lifeguards on Oahu estimated on average nearly 16 million beach visitors, compared with less than 1.2 million on Kauai, a ratio difference of 13.5:1. During the same time, Oahu lifeguards, numbering more than 200, recorded an average of 1,521 shoreline rescues, mostly from rip currents and rough water, compared with 226 for Kauai lifeguards, who number fewer than 50 (U.S. Lifesaving Association, 2009). Without question, lifeguards comprise a critical part of any water safety program, although lifeguards cannot ensure that no drowning deaths will occur. The United States Lifesaving Association has found that the chance of a drowning death at a beach with lifeguards trained to USLA standards is one for every 18 million beach visits (Brewster, 2003). Data for which such a ratio could be calculated for Kauai have not been obtained.

The following discussion and illustrations (Figures 16–19) of selected shoreline localities document many of the aspects of the uniqueness of Kauai's water safety situation, including the physical hazards, degree of accessibility, and presence or absence of lifeguards.

Table 1 Kauai Island Shoreline Localities With Greater Than Five Drowning Deaths 1970–2009

Beach or Area	Access	Drowning Deaths	Winter / Summer	Major Hazards
North Coast				
Polihale	semiremote	16	14 / 2	large surf; rip currents; longshore current
Kalalau	remote	7	5 / 2	large surf; rip currents; longshore current
Hanakapi'ai	semiremote	29	23 / 6	large surf; rip currents; longshore current
Kee*	easy	7	3 / 4	reef channel rip current; longshore current
Haena area*	easy	15	6 / 9	variable rough water—extended coastal area
Lumahai	easy	23	16 / 7	large waves; rock ledge; river mouth input
Queen's Bath coastal area	semiremote	7	6 / 1	large waves; narrow rock ledge
Anini	easy	11	8 / 3	reef channel rip currents
Kauapea	semiremote	6	4 / 2	large surf; rip currents
East Coast				
Larsen's	semiremote	11	5 / 6	reef channel rip currents
Molokaa	easy	6	2 / 4	bayhead rip currents
Anahola*	easy	6	3 / 3	bayhead/river mouth rip currents
Kealia*	easy	16	6 / 10	rough water; strong rip currents
Kapaa	easy	16	8 / 8	variable rough water—extended coastal area
Wailua*	easy	24	11 / 13	variable rough water conditions over extended coastal area; river mouth input
Kalapaki	easy	9	5 / 4	moderate variable conditions
South Coast				
Poipu area*	easy	36	18 / 18	variable surf conditions over extended coastal area; local rip currents

* localities with lifeguard stations as of 2009

North Shore Localities

The ten north shore localities listed in Table 1, four of which are also illustrated in Figures 16 and 17, account for 90% (129/144) of the 1970–2009 drowning deaths that have occurred along this 65 km long section of Kauai's shoreline from Polihale Beach on the west to Kilauea Beach at the northeast corner of the island (see Figure 9). They all are impacted by the large winter, North Pacific swell-driven surf, and associated strong wave-generated current conditions. Over two-thirds (99 of 144) of the drowning deaths on the north shore have occurred during the seven Hawaiian winter months of October through April. Each locality also possesses unique hazardous conditions that differ from those at other localities, mostly owing to the variable coastal geomorphic features and nearshore bathymetric settings. As of 2009, lifeguard stations are staffed at only three of the north shore localities, Hanalei Bay, Haena Beach, and Kee Beach, where each has had significant impact on reducing incidents of injury and drowning at their area of responsibility.

Polihale Beach, Kauai's westernmost beach and the State of Hawaii's largest single beach in terms of sand content, is a beach for beach purists. The hot, arid setting is one of the island's most isolated sites; however, it can be reached relatively easily most of the year by traversing 5–8 km of dirt road through abandoned sugar cane fields. Most drowning fatalities at this unguarded beach (14 of 16) have occurred during winter months when North Pacific Swell events create large waves that wrap around the west end of the island to generate extremely rough water conditions, including rip currents and a strong, southwestward-directed longshore current.

Beaches along Kauai's Na Pali coast have been some of the most deadly. Kalalau Beach and nearby Honopu Beach together represent one of the most remote shoreline localities that can still be reached on foot. A 17.5-km foot trail provides access along this coastline of scenic sea cliffs for physically fit individuals who usually carry their gear and supplies with them. The substantial 500–1000 m-long sandy beach at Kalalau Valley is impacted head on by winter, North Pacific swell-generated waves that create dangerous rip currents and a strong longshore current. Most (5 of 7) drowning deaths at this treacherous locality have occurred during winter months. The remoteness of this locality probably has been a factor in limiting the number of drowning deaths at these beaches. In numerous nonfatal drowning incidents, individuals hardy enough to hike the Kalalau Trail also have been able to survive the hazardous ocean conditions present in the near offshore area (*The Garden Island Newspaper*, various articles). The long stretch of sand at Kalalau Beach provides some opportunity of returning back to the beach if one is pulled seaward by a rip current and transported southwestward by longshore currents along the beach. Conditions in the ocean at the mouth of Hanakapiai Valley do not provide such an opportunity.

Although somewhat remote, the highly variable shoreline at the mouth of Hanakapiai Valley (Figure 16A) can be reached fairly easily by traversing the moderately rugged, 3.2 km long trail from the end of the road (Hwy 560) at Kee Beach. Because of such relative ease of access, this spectacularly beautiful but extremely hazardous shoreline locality has been one of the deadliest on Kauai since any records have been kept. A total of 29 individuals, all island visitors, have fatally drowned at this locality 1970–2009, 23 during hazardous winter surf conditions. Victims have been pulled offshore by rip currents and then swept westward by a

strong persistent longshore current along the high lava rock sea cliffs where there is no safe exit for over 5 km.

The swimming and snorkeling safety situation at Kee Beach is particularly unique. Easily reached by driving to the end of the road (Hwy 560) at the northwest end of the island (Figure 16B), hundreds of mostly island visitors visit this locality daily throughout the year. The beach is protected from ocean surf, even to a degree during winter months, by the prominent fringing reef platform of Kee Reef. The most dangerous situation at this locality occurs when the tide is dropping. Water that drains off the shallow reef platform from wave washover and from the lowering tide flows westward through the shallow swimming area behind the reef and surges out through a narrow channel that exists between the back edge of the reef platform and the Na Pali coast. Every drowning fatality that has occurred at this locality has been the result of a swimmer/snorkeler being carried out into the open ocean through that channel. Most Kee Beach drowning deaths have occurred during times when lifeguards were not stationed this locality. Fortunately, since 2008 the station at Kee Beach has been staffed daily by County lifeguards.

Lumahai Beach (Figure 17A), a short distance west of Hanalei Town on the north coast has commonly been rated as having the second or third highest fatal drownings of beaches on Kauai. A total of 23 individuals died by drowning at this locality over the 30-year period (1978–2009). Interestingly, only four of the 23 victims were of people actually going for a swim in the ocean. Ten (some walking or just standing to have their picture taken) were pulled off the east end rocky headland by North Pacific waves and drowned in rough water. Nine people drowned at the west end of the beach where Lumahai River enters the ocean. Lumahai Beach is an easily accessible, beautiful beach that is a major attraction on the island. Scenes in the famous 1950s movie “South Pacific” were filmed on this beach and many visitors are determined to visit the locality. Very few visitors are aware of the hazardous conditions that exist at this “must see” beach.

Figure 16 — Maps of shoreline localities along the northwest coast of Kauai emphasizing coastal features and major ocean hazards. North is at the top of each map.

Rimming the back of crescent-shaped Hanalei Bay, three kilometer-long Hanalei Beach is one of Kauai's most beautiful and most frequented sandy beaches, even recently being designated (2009) as the United States #1 beach by "Dr. Beach," Stephen Leatherman (www.drbeach.com). Rip currents, strongest and most abundant during winter surf conditions, commonly pull swimmers offshore into deep water and into trouble. Five of the eight drowning fatalities have occurred during the winter. As with such very popular beaches, the sheer number of visitors increases drowning death numbers, even with lifeguards staffing towers every day at a couple of locations in the bay.

One of the most uniquely hazardous areas of Kauai's coast is a wave-cut lava rock bench that rims a portion of the Princeville headland east of Hanalei Bay. The area is best known for a beautiful, shallow, seawater-filled, 30–50 m-long natural indentation in the rocky shoreline known as Queen's Bath (Figure 17B). The site can be accessed relatively easily by a coastal footpath. During summer months the pool is calm; however, during winter surf conditions, powerful waves easily wash into the pond over a small rock lip at its seaward margin. Onlookers, bathers, and swimmers can be readily washed out of the pool and into the turbulent ocean during such high surf conditions. Just getting to Queen's Bath can be the most dangerous part of the trip. Several visitors have been washed off the lava rock shelf by large winter waves.

Adding variety to Kauai's hazardous north shore is Anini Beach near the north-eastern corner of the island. The easily accessed, popular County beach park area is represented by Anini Reef, a shallow, commonly less than 1–3 m-deep platform extends more than half of a kilometer offshore along two to three kilometers of the coast. The principal hazard at this unguarded locality is the existence of permanent deep reef channels that extend from just offshore of the beach to the reef's seaward edge. Many unsuspecting swimmers/snorkelers have been pulled through such reef channels by seaward-directed currents and drowned in a rough open ocean.

Figure 17 — Maps of shoreline localities along the northeast coast of Kauai emphasizing coastal features and major ocean hazards. North is at the top of each map.

Not surprisingly, eight of the 11 drowning fatalities at Anini Beach have occurred during winter months.

East Shore Localities

The seven east shore localities listed in Table 1, two of which also are illustrated in Figure 18, account for almost all (88 of 92) of the 1970–2009 drowning deaths that have occurred along this most windward section of Kauai’s shoreline. All east shore localities face the persistent Northeast Trade Winds, which generate hazardous rough water conditions throughout the year. Collectively, there is no seasonal pattern to the number of drowning deaths at east coast localities. Significant geomorphic and bathymetric features at specific shoreline localities create variability that makes each locality unique with respect to hazards for beach goers and swimmers. In addition, popularity and relative ease of access, as well as the presence or absence of a staffed lifeguard station, are reflected in the numbers of drowning fatalities at specific localities.

Larsen’s Beach near the northeasternmost point of the island is a beautiful three-quarter kilometer-long sandy beach lying behind a narrow fringing reef platform (Figure 18A). Armed with simple driving and hiking directions, which are available in most guidebooks, this semiremote beach can be accessed rather easily. The main hazard here, of which few visitors are aware, is the narrowness of the shallow reef platform combined with the presence of prominent reef channels. Swift channel currents have carried swimmers into the open ocean within seconds with few options for returning to the beach. Every one of the eleven 1970–2009 drowning fatalities, 10 of them involving visitors to the island, were a result of such a reef channel current scenario. Most likely none of the victims had any knowledge of even what a reef channel is. No lifeguards have ever been stationed at this beach to inform them of the dangers.

Molokaa and Anahola bays are classic representative examples of the many drowned river mouth bays present around Kauai’s perimeter. Both are easily accessed. The beautiful County beach park at Anahola is frequented by both residents and island visitors. At both localities, the main hazard to swimmers is the development of rip currents, especially near the bay-center river mouths. All recorded drowning deaths at these two localities have occurred during times when lifeguards were not present to inform swimmers of rip currents and other hazards or to rescue them. Fortunately since 2008, an Anahola Beach lifeguard station is staffed on a daily basis.

The beach at Kealia (Figure 18B) is one of the island’s most hazardous swimming areas throughout the year. This kilometer-long sandy beach faces directly east into the sloppy rough water created by trade wind-generated waves. With no reef platform seaward of the beach, waves impact the beach full force. Hazardous rough water and rip currents dominate the shoreline. Lying immediately adjacent to Hwy 56 just north of populous Kapaa Town, Kealia Beach is one of the island’s most visited by both residents and visitors throughout the year. Essentially all of the sixteen 1970–2009 drowning fatalities and numerous nonfatal drowning incidents at this locality have involved rip currents and rough water, mostly during the years when a lifeguard station was not staffed. The lifeguard station now at Kealia Beach has prevented many injuries and drowning incidents since being staffed in 2002.

A five-kilometer long stretch of mostly sandy beach shoreline between Kealia Beach and Wailua Beach is fronted mainly by a broad shallow fringing reef platform, Kapaa Reef. The variability of conditions along this stretch of the coast makes delineation of specific hazards at specific locations a difficult task. Perhaps the most significant aspect here at this popular location is the presence of numerous resorts, extreme ease of access to the entire shoreline, and complete lack of lifeguards. The beach at Wailua Bay does display specific hazards and has been the site of numerous 1970–2009 drowning deaths (a total of 24), including several in the area of Lydgate State Park where a lifeguard station is staffed daily. County lifeguards assist beach goers and swimmers at that specific location; however, those visiting other portions of Wailua Beach are mostly on their own. Rip currents are common, but perhaps the most hazardous aspect of this area is the outflow of Wailua River. Strong river mouth currents have carried numerous swimmers seaward to their deaths.

South Shore Localities

The distribution of drowning deaths along the island's southern coast is more evidence of the complexity of the situation on Kauai regarding water safety. Over half (36 of 64) of the 1970–2009 drowning deaths have occurred in one main area, Poipu (Figure 19); all the other deaths occurred at 11 localities along the coast, some of them in rather isolated places. In general, surf conditions are less intense along this part of the island. Numerous South Pacific swell events occur throughout the five summer months of May through September, although such waves are much smaller than those of the winter North Pacific swell. Much of the south shore, especially the Poipu area, is easily accessible. S.C.U.B.A. diving is more popular along the south coast owing to the generally calmer ocean conditions year round

Figure 18 — Maps of shoreline localities along the east coast of Kauai emphasizing coastal features and major ocean hazards. North is at the top of each map.

as well as ease of access from the shoreline. As a result, drowning deaths involving S.C.U.B.A. diving activities account for nearly 20% (11 of 64) of all 1970–2009 south coast incidents of death by drowning.

The Poipu Beach Park lifeguard station has been present longer than any station on the island, beginning well before 1970; however, the number of drowning deaths that has occurred at beaches within the vicinity of the Poipu station is higher than at any other locality island wide. The causes of drowning and the water safety situation at the beach are complicated. The station is located in the center of the beach park, but lifeguards attempt to take on the responsibility of protecting beach goers and swimmers all along more than a kilometer of coastline having at least four specific beaches (Figure 19), several of which front popular resorts. The beaches are packed year round, both with visitors as well as with numerous island residents. A specific visitor destination organization, the Poipu Beach Resort Association, has actively promoted this area for more than 25 years. In 2001 Dr. Stephen Leatherman (known commonly as “Dr. Beach”) designated Poipu Beach as the United States’ “Best Beach.” Since that time the Poipu area has been the number one locality of drowning deaths on Kauai. Details regarding the hazards, such as waves, longshore currents, and rip currents are indicated in Figure 19.

The numerous other localities along the south shore at which drowning deaths have occurred (see Figure 9), also display a wide variety of conditions. With respect to water safety, each locality is a specific challenge. Each locality provides emphasis for the need to provide site-specific information regarding hazardous

Figure 19 — Map of shoreline in the vicinity of Poipu Beach, south coast of Kauai, emphasizing coastal features and major ocean hazards.

conditions in the nearshore marine area that can endanger individuals entering the water from the shore.

A History of Water Safety Activities on Kauai

To more fully understand Kauai's unique situation with respect to drowning deaths and water safety, I provide a brief review of the history of the island's water safety activities. Over the past 40 years, governmental (State of Hawaii and County of Kauai) and public activities on the island of Kauai regarding water safety and drowning prevention mostly have been reactive rather than proactive. Before 1970, tourism on Kauai was moderate compared with Oahu where localities like Waikiki were principal destinations. With relatively few visitors to Kauai, the majority of the island's ocean shoreline drowning deaths through the 1960s involved residents, commonly less than three or four per year. Many of the drowning deaths occurred at inland rivers, ditches, lakes, and swimming pools. In 1970, the County maintained lifeguard stations only at two island locations, Poipu Beach Park and Salt Pond Beach Park, both popular with residents.

As the annual number of visitors began to exceed 400,000 in the early 1970s and increased to over 800,000 by the end of that decade, aquatic accidents and death by drowning, most involving visitors, were being increasingly reported to the public in the island's local newspaper, *The Garden Island (TGI)*. By the late 1970s, ocean shoreline drowning deaths were occurring at the rate of eight to ten per year; the average annual rate for the decade of the 1970s was 5.5. As already reviewed, the average annual number of drowning deaths for each of the three decades since has continued to increase (Figure 11). The only major decrease in annual drowning deaths occurred in the years immediately following two major hurricanes, Iwa (November 23, 1982) and Iniki (September 11, 1992). Through the first decade of the new millennium, the annual average was greater than ten.

The 1970s: A Decade of Awareness

The 1970s might best be referred to as the "decade of awareness" with regard to Kauai's drowning deaths. Interestingly, the two incidents that first seemed to catch the public's attention were not associated with ocean shoreline drowning accidents, the principle topic of this paper. In December of 1970, eight fishermen disappeared in a boating accident off the nearby island of Niihau; their bodies were never recovered. In April of 1971, three teenagers on Spring vacation from the nearby island of Oahu died in a turbulent pool at the base of a private but commonly visited waterfall, Waipahee Falls (known locally as "Slippery Slide") on the Kealia River. As the result of these incidents, along with a growing number of ocean shoreline drowning deaths, the grassroots Committee on Water Safety (COWS) was formed to call attention to such tragedies and to explore ways to reduce them.

In 1972, with the exception of Poipu Beach Park and Salt Pond Beach Park, Kauai's beaches had no lifeguard protection or signage to warn or inform of ocean hazards in the nearshore marine setting. The activities of COWS directed attention to this lack of lifeguards on most beaches and to the absence of signage. Kauai Mayor Antone Vidinha instructed his own Committee on Water Safety to prepare proposals for improved water safety. An interim proposal from the committee

requested that four trained lifeguards, two full-time and two weekend-only, be hired and adequately equipped as soon as possible.

In August 1974, it was announced that the parents of one of the three boys who had died at the Waipahee Falls Slippery Slide three years before had lost their \$650,000 negligence lawsuit against the State of Hawaii in Circuit Court. This lawsuit and others that followed as a result of other nonfatal aquatic accidents (e.g., neck and spinal injuries resulting in paralysis) and drowning deaths eventually led to State legislative actions that have strongly influenced both State and County water safety programs to the present time.

Throughout the mid- to late-1970s, in response to an increasing number of drowning deaths, a few more lifeguards were stationed at Kauai's beaches. During the summer of 1976, twelve lifeguards were stationed at eight beaches: Haena, Hanalei, Anahola, Lydgate, Kalapaki, Brennecke's, Poipu, and Salt Pond. Over a two-year period from late 1977 through late 1979, nine visitors drowned at a single small beach, Hanakapiai Beach. Lifeguards had never been posted at the Hanakapiai shoreline. Proposals to provide hazard signage at Hanakapiai or even to completely close off wintertime access to this popular beach were put forth, but no action was taken to change the situation at this hazardous locality.

The 1980s: A Hurricane, Legislation, and More Committees

With the dramatic, late-1970s surge in ocean shoreline drowning deaths, activities aimed at drowning prevention and water safety heated up. The aspect of beach signage became a major point of contention between Kauai's County Council and then Mayor Eduardo Malapit. "Drownproofing" and "Learn to Swim" programs sprang up. A few more lifeguards were hired and placed on the more popular beaches during the summer months. Then on November 23, 1982, Hurricane Iwa made a direct hit on Kauai, smashing the island and severely crippling the tourism industry. Along with the sudden dramatic decrease in visitors, the number of drowning deaths dropped to the lowest in a decade (3).

By the mid-1980s, visitor attendance had rebounded and the annual number of drowning deaths was back to pre-Iwa levels along with renewed efforts to find ways to prevent them. In 1984, as a result of an increasing number of lawsuits, legislation was introduced to release the State of Hawaii from liability for injuries caused by natural conditions at public places such as beaches and streams. The government's approach to the problem of shoreline injuries and drowning deaths was prioritized as devising liability protections through legislation, which emphasized the legal responsibility to "warn," but not necessarily to "inform," the public of the hazards that exist in its nearshore ocean setting.

Through the mid- to late-1980s, two groups were formed on Kauai with drowning prevention and water safety as their focus. Both the Kauai Ocean Rescue Council (KORC) and the Kauai Water Safety Task Force (KWSTF) were created. KORC, initially formed to promote better safety practices for boaters at sea, became involved in all aspects of water safety, including the acquisition and donation of water safety equipment. In addition to numerous editions of a well-written column on water safety for *The Garden Island* newspaper in 1987–89, professional lifeguard and lifelong water safety advocate and practitioner, Pat Durkin, created and then continuously updated the first brochures and guides to Kauai's beaches, water

activities, and safety. Such guides are still being produced today with the intent of educating both visitors and island residents about the potential dangers of entering the coastal waters off the island's many easily accessible beaches. Much of the early signage on Kauai's beaches warning of wave and current hazards is the result of Durkin's efforts.

Since November 1989, perhaps the most influential water safety group on Kauai has been the Kauai Water Safety Task Force, composed of community leaders, health care providers, water safety advocates, and concerned members of the private sector and business community. Pat Durkin, the first chairman of KWSTF, and Art Tani, Health Department Injury Prevention Director, started the task force as an offshoot of the Health Department. Ralph Goto, Water Safety Administrator for the City and County of Honolulu, pledged his influential support for the mission of the task force early on and has remained a key member. Perhaps the most influential and persistent member of KWSTF has been local physician, Montague "Monty" Downs, who became cochairman in late 1992 and has continued in that capacity to the present.

The 1990s: Another Hurricane, Liability/Funding, More and Better Equipped Lifeguards, and a Plan

Throughout the 1990s, perhaps best titled "A Decade of Action," water safety on Kauai was influenced primarily by the governmental fear of multimillion dollar lawsuits and the supposition that increasing the number of lifeguards on a few beaches would stem the steadily increasing number of ocean shoreline aquatic accidents and drowning deaths. But again, it was another calamitous hurricane that had the greatest impact on decreasing those drowning numbers. An important legal distinction between "State" and "County" beaches was established during this decade.

In Hawaii, the State and Federal governments operate under the doctrine of governmental immunity, where the State can dictate circumstances under which it can be sued. Such immunity allows the State a considerable amount of flexibility with respect to protection from prosecution, applying in particular to aquatic accidents and drowning deaths occurring as a result of natural forces in the islands' coastal waters. By legislative action, the State, which is the legal owner of all beaches as well as the areas of rocky shoreline seaward of the high water line (commonly marked by coastal vegetation), also extended immunity to land owners whose property lay immediately landward of the shoreline. Counties do not operate under the same doctrine of governmental immunity and therefore are much more vulnerable to lawsuits stemming from shoreline aquatic accidents and drowning deaths. The designation "State Beach" or "County Beach" is determined by who owns/controls the land immediately landward of the beach and therefore access to the beach. In most cases, State beaches are seaward of State parks and County beaches rim County parks.

Only the County of Kauai provides for and manages lifeguards at the island's beaches, and up until the early 1990s, their lifeguards were stationed only at County beaches, full-time only at Poipu Beach Park and Salt Pond Beach Park and part-time at several other County beach parks. To protect the County from aquatic accident and drowning death lawsuits, expensive liability insurance was purchased in addition to funding their lifeguard programs. The State of Hawaii has never employed

lifeguards on Kauai and therefore has never guarded the island's State beaches. Until the early 1990s, the State also did not provide funds to the County to station lifeguards at State beaches. When the State finally did provide such funding, the situation with respect to water safety on Kauai became even more complicated.

After attempting to allocate State funds for several years to support the County's placement of lifeguards at some of the more dangerous, high-drowning State beaches, in 1990 the State Legislature finally approved an appropriation of \$1 million for such activity, almost half of that just for Kauai County. State liability protection, however, was not extended to the Counties as part of their reimbursed provisions for lifeguard services, making it necessary for the County to spend much of their appropriation on liability insurance.

On September 11, 1992, Kauai was smashed by powerful, force 5 Hurricane Iniki, severely crippling the island's infrastructure, especially its tourist service industry. The number of visitors dropped dramatically from annual levels of well over a million to less than half a million. Within a year, the annual number of ocean shoreline drowning deaths dropped from around 10 in pre-Iniki years (11 in 1990 and 9 each in 1989 and 1991) to 3 in 1992 and 4 in 1993. By the mid-1990s, visitor totals were back up to 750,000 or more per year and shoreline ocean drowning deaths rose again with nine in both 1994 and 1995.

At the end of June 1995, Mayor Maryanne Kusaka, under advisement by the County attorney, took one of the most significant actions ever regarding water safety on Kauai. She decided to refuse State money for lifeguards and their equipment at State-controlled Kee Beach, thus terminating lifeguard coverage at this hazardous location (see Figure 17B). The issue was that of liability, or more specifically, the fear of multimillion dollar lawsuits the County felt it could not afford. While dealing a devastating blow to the County lifeguard program on Kauai, this action by Mayor Kusaka generated publicity that eventually precipitated a significant expansion of the Kauai's water safety program through the latter part of the 1990s and into the first decade of the new millennium.

Legislatively, 1996 was a very significant year in Hawaii with respect to water safety. Act 190, Session Laws of Hawaii (SLH) 1996, was established for the State and County to require provision of both meaningful and legally adequate warning to the general public of extremely dangerous natural conditions in ocean areas adjacent to their respective public beach parks. The Act recognized a "duty to warn," specifically of "dangerous shorebreak" or "strong currents" in the ocean fronting a beach park, if either condition exists, is extremely dangerous, is typical for that beach park, and possesses a risk of serious injury or death. The duty to warn was satisfied by the placement of official beach warning signs. The Act also clarified that the State and Counties had no duty to warn of dangerous natural conditions at beaches, beach/coastal accesses, or areas that were not public beach parks. A Task Force on Beach and Water Safety was formed to advise the Chairman of the State Board of Land and Natural Resources on the design and placement of beach warning signs. Also in 1996, a second Legislative Bill, Act 170, was introduced, and, after two years of intensive lobbying, was passed into temporary law in 1999, with a "sunset" clause now set at 2014 in the event that the Act was found to not be useful and warranted. This Act still provides legal immunity for the County and County lifeguards when they guard or attempt rescues at beaches other than

“County Beach Parks.” For Kauai, Act 170 provided the foundation for once again guarding Kee State Beach with County lifeguards.

As a result of Act 190, beach warning signs popped up everywhere on Act 190 beaches, and many others never designated as such (see Figure 20 and Figure 21), even though it is well known that a surprisingly small percentage of people pay attention to signs and warning flags (see Brewster, 2003). The idea behind signage has been that if the government fulfills its “duty to warn” of potentially dangerous natural hazards, it becomes much more difficult for a victim, or the family of a victim, to sue the government for failure to warn. Of course the big void in all of that has been that the signs do little to “inform” or educate the beachgoer of anything about what such a hazard might be or what one should do if slammed in the beach by a “shorebreak” or pulled out to sea by a “strong rip current.” Signage expert and Honolulu Water Safety Administrator, Ralph Goto, summed it up when he was quoted in a Honolulu newspaper as saying that “. . . there has never been a case where a sign was able to jump in the water and pull someone out.”

Other significant developments in drowning prevention and water safety on Kauai in the 1990s included (a) the convening of two on-island meetings of the biannual State-wide conference on Drowning Prevention and Water Safety in 1993 and 1997; (b) the introduction (1993) and acquisition (1995) of personal watercraft for use by lifeguards in ocean rescues; and (c) preparation by the Kauai Water Safety Task Force, at the request of Mayor Maryanne Kusaka in 1996, of a five-year plan to build up Kauai’s water safety program. The KWSTF plan, implemented by the end of the decade, resulted in the increase of guarded beaches to eight with stations staffed by nearly 20 well-equipped, full-time and 10 part-time lifeguards. For greater efficiency, water safety personnel were reorganized as the Ocean Safety Bureau (OSB) within the Kauai County Fire Department. The Bureau’s intensive lifeguard selection and training program and its Junior Lifeguard Program, initiated in 1999, resulted in a substantial increase in professionalizing the lifeguard group. Unfortunately, by the end of the decade, the numbers of drowning deaths also were at record levels; more than 10 people, mostly visitors, were dying each year at Kauai’s ocean shoreline.

2000–09: Websites, Guidebooks, More Lifeguards, Meetings and Programs, Along With Record Numbers of Drowning Deaths

With the County’s five-year water safety plan adopted and in action, drowning prevention on the island at the beginning of the new millennium looked promising. Unfortunately, the many aspects that make Kauai unique with respect to the prevention of ocean shoreline drowning deaths were still in place. Annual aquatic accidents resulting in death continued to rise through the decade to their highest levels ever.

Information on the amazing attributes of Hawaii, in particular Kauai, as a vacation destination has never been more easily accessible, thanks to the internet and numerous attractive guidebooks. Both the Hawaii Visitors and Convention Bureau (HVCB; www.gohawaii.com) and Kauai Visitors Bureau (KVB; www.kauaidiscovery.com) market the islands aggressively with their beautiful, comprehensive websites; however, little or no information is provided as to the hazardous nature

Figure 20 — Example of warning signs placed at beaches by the Kauai County Ocean Safety Bureau. Individual warning signs are all approximately the same size (18 × 24 inch; 46 × 61 cm). Similar signs are present at both the shoreline localities that have had the most drowning deaths as well as those that have had the least drowning deaths. Note the following number of drowning deaths that have occurred at each of these localities, 1970–2009 A. Polihale–16, B. Queen’s Bath–7, C. Hanakapiai–29, D. Kealia–16, E. Poipu–36, F. Salt Pond–2.

of Hawaiian coastal waters. The KVB Kauai Discovery site does include a link to the Ocean Report of the Kauai Explorer website but does not emphasize anything about the well-known dangers of entering the ocean. In addition, there are numerous websites marketing accommodations, products, and activities of all types. A plethora of online blogs and bookstore guidebooks provide information on all

Figure 21 — Examples of unofficial warning signs placed at beaches by private individuals and by resorts. A. Hanakapiai Beach, B. Queen's Bath, C. Hyatt Regency Hotel at Keonelo Beach, D. Sheraton Resort Beach, Poipu.

kinds of things to see and do, including how to access beaches and other relatively remote shoreline localities. Such information undoubtedly has contributed to the increasing number of aquatic accidents.

Through the first few years of the new millennium, the annual number of visitors actually showed a minor decrease, hovering around 900,000 for the first five years, likely as a consequence of the terrorist attacks on September 11, 2001 and then the Severe Acute Respiratory Syndrome (SARS) pandemic that occurred between November 2002 and July 2003. After 2005, the number of visitors to Kauai was

again well above a million per year, exceeding 1.2 million by 2007. Along with the considerable number of visitors, the number of drowning deaths climbed to record annual levels, averaging more than 10 per year over the first decade of the millennium, 2000–2009. The 16 ocean shoreline drowning deaths in 2008 represented the highest ever recorded on Kauai for a calendar year. The continuing numbers of aquatic accidents and fatalities provided the impetus for continued expansion of Kauai's water safety programs. The number of full-time lifeguards and support staff in the newly established Ocean Safety Bureau increased to as many as 45 with guards staffing stations at 10 beaches.

Along with the formal surge in the County's professional lifeguard force, there have been a number of significant activities focused on calling attention to and attempting to allay the shocking increase in nearshore marine drowning deaths. In 2008, the biannual conference of the United States Lifesaving Association was held on Kauai and was well attended by lifesavers from throughout the country. Water Safety Week, promoted the last week in May, became a statewide affair in 2007 after being initiated as just a Kauai countywide event the year before.

Beginning in 2008 rescue tube type flotation devices were placed at nearly 40 shoreline localities, mainly beaches, around the island with the hope that they could be used to help save someone from drowning in both guarded and unguarded places. As of early August 2010, nearly 90 rescue tubes had been placed at various shoreline localities around the island, each with an informational placard explaining its use, various aspects of rip currents, the importance of calling 911 for assistance, and how to attend to a drowning victim (Figure 22). According to Monty Downs (personal communication, August 2010), tubes had been used in numerous incidences involving a rescue of someone in a nonfatal drowning situation.

Beginning in 2002, a website (www.kauaiexplorer.com) was initiated to raise the awareness of the public about ocean hazards and daily surf conditions at Kauai's beaches. The countywide site, created by web designer and former fireman, Winston Welborn, has become the standard for providing daily or even more frequent information on shoreline conditions. Since then, websites dealing with water safety have been established statewide by the Hawaiian Lifeguard Association (www.aloha.com/~lifeguards) and the University of Hawaii School of Ocean and Earth Science and Technology (www.oceansafety.soest.hawaii.edu). In late 2006, the ever-present water safety advocate, Pat Durkin, designed and launched an ocean safety program, WAVE (Water Awareness Visitor Education), specifically to educate the island's tourist industry. Durkin has educated numerous establishments about the importance of informing the island's guests about the potential dangers of entering the ocean. Obviously the goal of this significant educational program is and will continue to be to provide as much information as possible for resorts and other island destinations on island water safety to decrease the unacceptable rate of visitor aquatic injuries and drowning fatalities. Plenty of dedicated individuals continue to work on "the problem;" unfortunately, all efforts combined have not yet had the intended impact.

A Tale of Two Shorelines

An illustration of the extremely complex situation regarding water safety on Kauai can be provided by a review of the drowning deaths that have occurred over the

Figure 22 — Photos of A, rescue tube at beach location and B, placard posted with rescue tube explaining its use, various aspects of rip currents, the importance of calling 911 for assistance, and how to attend to a drowning victim.

eleven-year period 1999–2009 at just two shoreline settings located on opposite sides of the island with significantly contrasting characteristics: Princeville’s Queen’s Bath and the south shore’s Poipu Beach (see Figures 17B and 19). During this 11-year period, 114 people died by drowning at more than 30 ocean shoreline localities around the island, but Queen’s Bath and Poipu Beach stand out.

On the north, the somewhat remote area known for its infamous little coastal pond, “Queen’s Bath,” has attained notoriety as one of the most treacherous localities on the island owing to a rash of injuries and dramatic drowning deaths in the area of the pond. Glowing information about Queens’s Bath, “an undiscovered north shore gem” (Doughty and Friedman, 1994) and detailed directions to the locality have been provided in several guidebooks since the mid-1990s and now are available

in numerous blogs and other sites on the internet. Seven adults (33–68 years old), six of them visitors, died by drowning in this area during the period 1999–2009, all but one during winter surf conditions. A local male resident was the first to die on January 1999 near the pond while scraping opihi limpet shells off the lava rock ledge in the narrow intertidal zone. The one summer drowning victim was a visitor who got in trouble when he snorkeled into the area from Hanalei Bay, a few hundred meters to the west. Only one of the victims was actually washed out of Queen's Bath by winter surf; however, another was pulled out of a similar nearby pond known as "Turtle Cove." Three visitors merely walking along the 3- to 6-m high coastal lava rock shelf were pulled off by winter surf and died in the turbulent ocean within 30 m of the shore. For years, local government officials have pondered closing access to Queen's Bath, especially during winter months, but to date have not done so. In spite of numerous warnings about its treacherous nature during high surf conditions, each year hundreds of adventuresome, but perhaps inadequately informed, visitors continue to find their way to this beautiful, but sometimes deadly place. No lifeguards presently staff Queen's Bath.

The beautiful, easily accessible beaches of Kauai's southern coast contrast dramatically with the remote rocky ledges of Princeville's Queen's Bath. A low coastal plain extends east-west for several kilometers along the south shore area known in general as "Poipu," at the center of which is Poipu Beach Park (Figure 19). A relatively shallow shelf, up to only a few meters deep at its seaward edge, extends offshore for several hundred meters to a reef ledge that generates several popular surfing breaks along the coast. The area is well known, easily accessible, and highly populated throughout the year. The popularity of the several beaches within the vicinity of Poipu Beach Park is unsurpassed on Kauai. The beach seems to show up every year on the top ten list of many travel publications, and was even designated as the United States' "Best Beach" in 2001.

With respect to the tourist service industry, one of the County's biggest mon-eymakers, Poipu, is an important place. The safety of the island's guests visiting the Poipu Beach area is a prime concern for the County. The lifeguard station at Poipu Beach has been staffed for longer than any of the island's beach stations since before 1970. Even with the smaller waves and wave-generated currents relative to Kauai's other coasts, the Poipu Beach area has suffered the island's highest number of drowning deaths during the 11-year period, 1999–2009. A total of 15 swimmers/snorkelers died in the shallow nearshore waters fronting the beaches of Poipu. The victims included 14 visitors, ranging in age from 50 to 86, and one local spear fisherman, age 22. In addition, five surfers and one kayaker, only one a visitor, died in the waters offshore of the Sheraton and a mile west down the coast in front of the Prince Kuhio and Lawai Beach resorts. Four people, three of them visitors, died while S.C.U.B.A. diving in the nearshore waters west of Poipu Beach Park at Koloa Landing, Prince Kuhio Resort area, and Kukuiula Harbor a mile westward along the coast.

The 25 drowning deaths in this one small area during the 1999–2009 period therefore represented more than one-fifth of the drowning deaths island wide, during which time 114 people died by drowning, 74 of them visitors, at more than 30 ocean shoreline locations. That is a shocking statistic considering that Poipu is a somewhat less hazardous ocean setting, compared with the rest of the island, and has one of the best staffed and equipped lifeguard towers on the island.

Summary, Comments, and Recommendations

Through the four decades from 1970 to 2009, a total of 300 people fatally drowned in the tropical nearshore marine waters of the Island of Kauai, Hawaii. The rate of drowning deaths increased from an average of 5.5 during the decade 1970–79 to greater than 10 during the first decade of the new millennium, 2000–09. A total of 16 shoreline-drowning deaths occurred in 2008, the highest annual number ever recorded for the island. These deaths occurred in spite of the increase in the number of lifeguards from a minimally-equipped handful staffing two shoreline stations in the early 1970s to an island water safety bureau composed of nearly 50 well-equipped lifeguards staffing as many as 10 shoreline stations by the end of the period of time covered in this case study. This paradox reflects the uniqueness of Kauai's situation with respect to water safety and drowning prevention. The approach to water safety and drowning prevention for the island should be unique as well.

There are many shoreline localities on Kauai at which people can get into trouble and few lifeguard stations are staffed with water safety personnel available to advise and watch over them. Individuals intending to venture into the nearshore marine setting, especially at an unguarded site, need to do so armed with information adequate to maintain their safety. Fundamentally, anyone venturing into the ocean needs to comprehend that they are an air breathing land mammal. The ocean is not a natural environment for humans. It is a foreign environment that can be hazardous to their well-being. People entering the water at any specific location should have site-specific information related to the potential and unique hazards of that location. Along with being warned of potential ocean hazards by generic signs, individuals need to be empowered with knowledge of specific hazards known to be present at the specific site they are entering. Perhaps more importantly, they need to know what they should do in the case that they are caught up in a hazardous situation. Empowering information needs to be on-site and site-specific.

There is a valuable concept in water safety known as the “drowning chain” (Figure 23) that can be applied directly to the situations on Kauai. Originated by Whatling (1994), it has been modified to the following series of conditions that, on their own or together, can lead to a person drowning:

- ignorance, disregard, or misjudgment of danger;
- uninformed or unrestricted access to the hazard;
- lack of supervision or surveillance; and
- inability to cope.

A break at any link in the chain can prevent a drowning fatality. At many of Kauai's nearshore marine locations, at least one or two links in this chain are maintained before individuals step out of their vehicle and approach the shoreline. It is likely that in most cases the first link, ignorance, is present even before a visitor reaches the island. Few visitors are aware of the hazards that exist in the nearshore marine waters of Kauai. For the most part, tourists are not stupid, they're ignorant; they lack knowledge about the specific water safety hazards and risks. If they possess knowledge of the hazard and disregard it, proceeding in an unsafe manner, then they still have not broken the first link. The second and third links are maintained when they approach one of the easily accessible, but unguarded and unsupervised,

Figure 23 — The drowning chain, a series of conditions that on their own, or together can lead to a person being drowned. Each link in the chain can lead to another link, or directly to a drowning (modified from Whatling, 1994).

shoreline localities. The final link is established when individuals find that they are unable to cope with the powerful waves and strong currents of Kauai's nearshore marine setting, even if they are swimming at a guarded beach.

Another important concept that needs to be applied to the water safety situation on Kauai is that of a "paradigm shift" (Kuhn, 1970) in which the thinking about a situation changes in a revolutionary manner. A transformation in thinking about Kauai's water safety situation would appear to require such a paradigm shift. Transferring information on the hazardous nature of Kauai's nearshore marine setting from those who possess knowledge to those who do not could represent such a shift. In other words, one place to break the drowning chain is at the information-education link. A principal recommendation of this paper is that informative site-specific and hazard-specific signage, perhaps in the manner of an informational kiosk, needs to be placed at as many shoreline localities around the island of Kauai as possible. Signage needs not only to fulfill the "duty to warn," providing liability protection for the State and County governments, but also to inform of the specific potential hazards present at each locality. Signs should be well located at principal points of contact with shoreline destinations, including along easily accessible beaches, and at the head of trails leading to remote localities. These notices should be of effective size, well designed, attractive and durable, and would need to be well maintained. At present such signs do not exist on Kauai, although the recently placed rescue tubes and associated informational placard go a long way to fill the void of informative signage (Figure 22). Providing easily accessible critical safety information might allow individuals the opportunity to recognize existing shoreline hazards and, even more importantly, to gain knowledge as to what to do if a hazard is encountered. Swimmers might learn to recognize a reef channel and know to avoid it or to learn how to exit a rip current by swimming parallel to the beach if they were being suddenly swept offshore. Certain areas might be approached with greater caution if a sign at the trailhead identifies that the beach approached is one of the island's four or five most deadly in terms of the number of drowning deaths that have occurred there. They might think twice, and more respectfully, before walking out on a rocky point on the north shore in the winter if they have knowledge that more than 10 people had drowned there as a result of being pulled into the ocean by periodic giant waves during the same time of the year. Instead of having warning signs that tout the catchy phrase "If in Doubt, Don't Go Out," point of contact informative signs might provide individuals with the knowledge

to self-generate the doubt that stops them from going out at a known unsafe time (see Figure 21).

Of course, informative signage spread around the island alone would not provide a panacea with respect to water safety and drowning prevention. A multi-pronged approach must continue. Well-trained lifeguards must continue to staff well-equipped stations, perhaps at even greater than current levels. Kauai's lifeguards have made many daring rescues and command an admirable history of saving lives. It is impossible to estimate how many fatal drownings might have occurred on Kauai had our lifeguards not been there; it is conceivable that there could have been more than twice as many deaths. Beachfront resorts should be enlisted to support the water safety efforts on the island by providing site-specific water safety information to their guests. Project WAVE (Water Awareness Visitor Education), created and promoted by advocate Pat Durkin, supports that effort; programs like Durkin's need to be expanded. In the future, it would be even better if such resorts became more active by training their own water safety personnel to advise and, if necessary, to rescue their guests. Ocean safety brochures and similar informative material must continue to be made available to visitors. Videos on airplanes inbound to Hawaii, at airports, and in hotel rooms need to continue to provide specific information as to the hazards associated with each of the island's nearshore marine settings. Websites, such as those of the Kauai Explorer site (www.kauaiexplorer.com), the Hawaiian Lifeguard Association (www.aloha.com/~lifeguards), and the University of Hawaii School of Ocean and Earth Science and Technology (www.oceansafety.soest.hawaii.edu) must be more promoted to island visitors and residents alike. To enact a real paradigm shift in the approach to water safety on Kauai, government and private organizations charged with the task of attracting tourists to the islands, such as HVCB (the Hawaii Visitors and Convention Bureau), KVB (the Kauai Visitors Bureau), and PBRA (Poipu Beach Resort Association) must embrace the concept that water safety does not begin at the beach. It must begin with the initial planning stage to visit Kauai. Such organizations must acknowledge that hazards exist in Kauai's coastal waters year round, that drowning is the number one cause of accidental death and that ill-informed visitors are the most vulnerable. After such acknowledgments, these organizations, using an open, honest, constructive approach, could then begin to provide visitors and residents with information to assist them in being active but safe participants in their visits to the nearshore marine waters of Kauai. An island water safety program that incorporates such features would be one that demonstrates response to the uniqueness of its situation.

References

- Barger, K.E., & Jackson, E.D. (1974). Calculated volumes of individual shield volcanoes along the Hawaiian-Emperor chain. *Journal of Research of the U.S. Geological Survey*, 2(5), 545–550.
- Bascom, W. (1980). *Waves and beaches*. New York: Anchor Books.
- Blay, C. & Siemers, R. (2004). *Kauai's geologic history: A simplified guide*. Poipu Kauai: TEOK Investigations.
- Brewster, B.C. (Ed.). (2003). *Open water lifesaving: The United States Lifesaving Association Manual* (2nd ed.). Upper Saddle River, NJ: Pearson Custom Publications.
- Caldwell, P.C. (2005). Validity of North Shore, Oahu, Hawaiian Islands surf observations. *Journal of Coastal Research*, 21(6), 1127–1138.

- Caldwell, P.C., & Aucan, J.P. (2007). An empirical method for estimating surf heights from deepwater significant wave heights and peak periods in coastal zones with narrow shelves, steep bottom slopes, and high refraction. *Journal of Coastal Research*, 23(5), 1237–1244.
- Clague, D.A. (1996). The growth and subsidence of the Hawaiian-emperor volcanic chain. In A. Keast & S.E. Miller (Eds.), *The origin and evolution of Pacific Island biotas, New Guinea to Eastern Polynesia: patterns and processes* (pp. 35–50). Amsterdam: Academic Publishing.
- Doughty, A., & Friedman, H. (1994). *The ultimate Kauai guidebook*. Lihue, Kauai: Wizard Publications.
- Jurvik, S.P., & Jurvik, J.O. (Eds.). (1998). *Atlas of Hawaii* (3rd ed.). Honolulu: University of Hawaii Press.
- Kuhn, T.S. (1970). *The structure of scientific revolutions* (2nd ed.). Chicago: The University of Chicago Press.
- Moberly, R.J., & Chamberlain, T. (1964). *Hawaiian beach systems*. Hawaii Institute of Geophysics, Technical Report 64-2.
- Moran, K. (2010). Risk of drowning: The “iceberg phenomenon” revisited. *International Journal of Aquatic Research and Education*, 4, 115–126.
- The International Life Saving Federation. (2007). International Life Saving Federation World Drowning Report. *International Journal of Aquatic Research and Education*, 1, 381–401.
- The International Life Saving Federation. (2009). *Drowning facts and figures*. Available at: <http://www.lisf.org>.
- United States Lifesaving Association. (2009). *Statistics*. Available at: <http://www.usla.org/Statistics/public.asp>.
- van Beeck, E., Branche, C., Szpilman, D., Modell, J., & Bierens, J. (2005). A new definition of drowning: Towards documentation and prevention of a global public health problem. *Bulletin of the World Health Organization*, 83(11), 853–856.
- Vitousek, S., & Fletcher, C.H. (2008). Maximum annually recurring wave heights in Hawaii. *Pacific Science*, 62(4), 541–553.
- Whatling, S. (1994). *Beach lifeguarding*. Warwickshire, UK: Royal Life Saving Society.
- World Health Organization. (2007). *2007 fact sheet on drowning*. Geneva, Switzerland: Author.