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Shifting shorelines and political winds – The complexities of implementing the simple idea of shoreline setbacks for oceanfront developments in Maui, Hawaii

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A B S T R A C T

Building out of harm's way is a simple, precautionary, logical idea that respects the ocean's power along dynamic coastlines. Maui has more beaches than any island in Hawaii, attracting tourists and oceanfront investment. In the late 1960s, with the islands agrarian economy of sugar cane and pineapple exports faltering, the County's leadership began marketing its coastal resources as a destination economy, beaches chief among them (Chu, 1965). The Island built a destination development economy out of its beaches, unique coastal resources and access to ocean recreation (HTA, 2005). Good planning and foresight by the local municipal county government could have protected these natural assets, thereby sustaining the island's development. Instead, the county relied on a standardized building setback policy that failed to account for erosion prone areas.

Four decades later, realizing the impending loss of the island's premier asset, namely beaches and access to the shoreline, the County moved to site-specific erosion-rate based setback policy. Government regulatory action, including setbacks for constructing buildings along the shoreline, form an integral part of the community's response to climate change and sea level rise (Codiga et al., 2011). The erosion-based setback policy, now a decade old, encountered numerous problems with its implementation. This led to delays in government permitting of oceanfront development and a number of time-consuming amendments to revise the policy. Here we present the unanticipated outcomes of the policy's implementation, particularly challenges to demark the shoreline setback area and delineate erosion prone areas. We also discuss the inherent problems encountered when applying the method to properties with ocean on more than one side or irregularly shaped parcels and situations where cliffs or bluffs rise from the sea.

With proper foresight, a destination economy can sustain its growth for years to come by prudently planning for coastal hazards while retaining the natural assets that formed the basis of their destination economy. We conclude by offering lessons learned from experience implementing shoreline setbacks that that will help coastal planners, practitioners, regulators and policy makers save time and avoid mistakes and delays when considering oceanfront development policies.

1. Introduction

The island of Maui is one of the top tourist destinations in the State of Hawaii, United States (US) owing to its long, beautiful sandy beaches and clear ocean waters. Maui has been voted "Best Island in the World" by the readers of Condé Nast Traveler magazine for 17 of the last 23 years (MVB, 2009) and one of the "World's Best Islands" by the readers of Travel + Leisure magazine for many years (Fischer, 2012). Tourism and destination development provides 41% of the islands jobs and 39% of the county's gross product (HTA, 2005). Yet, the island is subject to coastal hazards including storm surge, coastal flooding, tsunamis, high winds, large surf, acute and episodic erosion events, and chronic coastal erosion. Maui's shoreline is dynamic and can change rapidly in response to these natural forces leading to dramatic beach loss. Like other destination developments, hotels, condominiums, and vacation homes risk exposure to these coastal hazards and the natural dynamics of the beach if they are located too close the ocean (Cooper and Lemckert, 2012).

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When erosion threatens the built environment a common reaction is to armor the shoreline to protect private property (Gabriela and Terichb, 2005; Fletcher et al., 2012). This in turn, can degrade habitat, hinder sand transport, impound sand reservoirs, and increase wave turbulence and reflection (Fletcher et al., 2012). Installing armoring along a chronically eroding beach often leads to the construction of additional armoring on adjacent and down drift properties. The cumulative impact of a proliferation of seawalls, revetments and groins adversely effects sediment transport and sand resources leading to narrowed beaches and the loss or obstruction of access along the shoreline (Omar et al., 2009; USGS, 2012).

Furthermore, sea level rise from thermal expansion of ocean waters is causing the shoreline to retreat inland in Hawaii (Fletcher et al., 2011). Rising water levels are one of nature's primary tools for reshaping beaches and migrating them landward with waves and storm surges altering Hawaii's beaches daily (ibid.). In contrast to continental US beaches, Hawaii's beaches primarily consist of small embayment's between rocky or clay headlands (USGS, 2012). The width of Hawaii's beaches is maintained by sand reservoirs that are stored in backshore areas provided sand transport within the littoral cell operates naturally. This preserves beaches and coastal recreational amenities while allowing the shoreline to migrate naturally inland. Interruptions in this process lead to narrower beaches and lost access to coastal resources and amenities along the shoreline.

Assessing, the overall vulnerability of coastal counties involves the union of social, economic, built-environment, and physical characteristics (Boruff et al., 2005). For local planning, a risk assessment methodology could be employed to account for increased risks caused by sea level rise and increased storm frequency and intensity (Walsh et al., 2004). Planning in urbanized coastal areas also needs to account for rising water levels because its effects will be apparent during the typical replacement time of infrastructure such as sewers, storm drains and coastal roads (i.e., 70 years) (ibid.). But the methods for combining these components into useful policies are not widely used by coastal scientists and policy makers (Boruff et al., 2005). A viable mechanism is needed to minimize damage to habitable structures from coastal hazards while protecting beaches and shoreline access. Prudent planning policy would facilitate managed retreat where new buildings are constructed out of harms way by avoiding erosion and flood prone areas. As many coastal communities can attest, inappropriately situated buildings are more vulnerable to coastal hazards and when damaged, jeopardize public health and safety and risk loss of life and property (Garland, 2010). Yet, by managing development and redevelopment along the ocean, destination development coastal communities can accommodate retreating shorelines while retaining the public, economic and natural benefits beach assets create.

2. Practice and theory

In theory, building out of harm's way would avoid coastal hazards and thereby reduce degradation to public trust coastal resources that are enjoyed by society, tourists, retirees and the community at large in a destination development economy such as Maui's. Requiring new buildings to be constructed inland from the ocean, or setback from the shoreline, should reduce the likelihood that the structure will be damaged by coastal hazards during the building's lifespan. Creating a buffer between new buildings and the ocean allows coastal processes, such as sand transport and beach erosion, to occur naturally and be unhindered (Spahn, 1995; Hwang, 2005). Such a buffer could accommodate storm surge, high wave events, and sea level rise without jeopardizing the building or its inhabitants, and can protect public trust assets such as lateral access along the shoreline for recreational use of beaches, surf spots, near shore fishing and algae (*limu*) harvesting.

This theory was first actualized in 1971 with the enactment of the Florida Beach and Shore Preservation Act (Purpura, 1975). The State's legislature recognized the coastal zones crucial economic importance and that its development poses unique problems for land use regulation and planning (Maloney and O'Donnell, 1977–1978). The law restricts building construction in hazardous coastal hazard areas based on a Coastal Construction Control Line or CCCL (CC-EAR, 2003). The CCCL helps protect the natural environment from improperly sited or designed structures that can jeopardize the stability of the beach-dune system, accelerate erosion, reduce protection to upland structures, endanger adjacent properties, and interfere with public beach access and sea turtle nesting (FL-DEP, 2006).

North Carolina first evaluated long-term average annual erosion rates for its 300-mile (483 km) shoreline in 1979. Shoreline setbacks for building construction are measured from the first line of stable natural vegetation to help retain the natural buffering of coastal hazards by sand dunes (NC DENR, 2010). Initially, the setback distance was based on multiplying that annual rate of erosion for a particular beach segment by a factor related to the sites land use designation (residential, multi-family, commercial). But this system was recently revised to better reflect a building's lifespan based on its size rather than its use. Now the setback is calculated based on 30, 60, and up to 90 times the annual erosion rate for structures less than 5000, 10,000, or 100,000 in square footage (464, 929, or 9290 m^2), respectively (NC DENR, 2011). The minimum setback distance is 60 feet (18.3 m).

Along South Carolina beaches, new buildings must be located inland of the crest of the primary dune based on 40 times the annual erosion rate in that area. Buildings are limited to a maximum of 5000 square feet (464 m^2) and can have no impact on the primary sand dune or active beach area. If the beach erodes and the building becomes situated on the active beach, the building has to be removed at the property owner's expense (SC DJEC, 2012). This shifts part of the risk of building near coastal hazards to the landowner.

In Hawaii, the shoreline is defined as the highest wash of the waves during the highest tide of the year, excluding named storms and hurricanes. The first stable vegetation or the debris line normally identifies the shoreline's location (CZMA, 1997). Seaward of the shoreline is within the public trust domain and under the jurisdiction of the State Department of Land and Natural Resources (DLNR). Setbacks for building construction begin at the shoreline and extend inland. Statewide, the minimum setback is 20 feet however each county or island may expand the setback distance.

Overall, 14 of 35 coastal states in the US incorporate the history of shoreline fluctuation over time or building lifespan into shoreline setback determinations (Genz, 2006). In comparing state setback permitting programs, the most desirable features were designation of "low" and "high" hazard areas; consideration of structure size in determining the setback distance; and the setback program was understandable to the public (Houlahan, 1989).

In practical terms, determining the correct size of the shoreline setback to accommodate dynamic shorelines and buffer sea level rise could be challenging when the coastline is comprised of different geomorphologic forms such as sandy beaches, clay bluffs, rocky headlands, and sheer volcanic cliffs, each of which responds differently to wave action, coastal storms and natural forces.

One strategy is to calculate how much the shoreline has changed over the past and use these findings to estimate the shoreline's likely position in the future (Fletcher et al., 2012). The setback for oceanfront development could then be sized according to a building's expected lifespan. The difference in the shoreline's present and future position could serve as a setback or buffer for new building construction. As a result, the building would be located out of harm's way thereby decreasing its exposure to coastal hazards and reducing the negative impacts that result when buildings and habitable structures are located too close to beaches, valued coastal amenities, and recreational resources that may be lost due to inappropriate shoreline hardening to protect the built environment (ibid.).

On a stable coastline, the long-term change in the location of the shoreline should remain fairly constant except for the varying reach of the waves due to seasonal weather patterns and the ebb and flow of tides. A traditional uniform or standardized setback distance should be sufficient to account for this small amount of variance. However, on dynamic or chronically eroding shorelines, a more site-specific setback that accounts for erosion prone areas would be more logical. Based on this strategy, the ocean and beach could gradually move inland reaching the building around the time it has reached the end of its usefulness. At that juncture, the building could be demolished or relocated and the process repeated without negatively impacting the beach or sand resources. The calculated setback should also include a buffer to accommodate for sea level rise and seasonal change in the shoreline's position.

To enact this strategy, an accurate assessment of the shorelines past, present and future location is required. A prediction of how long a particular building or structure is expected to last based on its planned obsolescence is also necessary. When combined, the resulting shoreline setback for building construction encourages sustainable oceanfront development that avoids harm from coastal hazards and reduces the potential for negative impacts on coastal resources and sandy beach assets. The strategy, if properly implemented, bypasses the need to erect shoreline armoring to protect the built environment, thereby avoiding its negative effects on beaches and shoreline access. The strategy protects a landowner's building investment while protecting the natural assets that frequently make oceanfront property valuable, sandy beaches and shoreline access (Gabriela and Terichb, 2005).

Neglecting to account for chronic erosion and flood prone areas has consequences. In the United States, erosion could claim as many a quarter of the homes that are within 500 feet (152 m) of the shoreline over the next sixty years (Heinz, 2002). Without minimum building setbacks from the ocean, landowners incur costs to repair structures damaged by coastal hazards or costly solutions to protect oceanfront lands such as constructing seawalls, groins or revetments (NC DENR, 2011; Shows, 1978; Heinz, 2000). These types of erosion response can interrupt sand transport processes resulting in narrowed beaches, reduced water quality, and obstructions to access to the shoreline for the owner and along the shoreline for the public (OCRM, 2007; NRC, 1995).

Based on Maui's experience, the idea of building out of harms way is a simple, but translating that idea to decipherable regulation and cogent policy is not. After discussing the history of the policy's development, we offer examples that illustrate several challenges to implementing site-specific shoreline setbacks that practitioners should be mindful of.

3. Shoreline setback history

3.1. Hawaii's legal framework

The 1970 Hawaii State Shoreline Setback Law established minimum shoreline setbacks of 20 feet (6.1 m) for building construction (Tom, 2005). In 1973, Maui County expanded the setback to 40 feet (12.2 m) in cases where a lot was more than 100 feet deep (30.5 m). Recognized the inherent connection between the land and the sea the 1977 Coastal Zone Management Act (CZMA, 1997) granted authority for approving development within Shoreline Setback Areas (SSAs) to each county (Callies, 2010). The State Shoreline Setback Law was merged into the CZMA in 1986 consolidating the county's SSA permitting authorities into one law, with one set of penalties, and granted each Island's planning commission the authority to expand shoreline setbacks beyond the state's minimums. In 1990, the Commission revised the setback requirements to a minimum of 25 feet (7.6 m) for lots 100 feet (12.2 m) in depth; 40 feet (12.2 m) for lots 100–160 feet (12.2–48.8 m) in depth; and 25% of the lot's depth for larger lots; with a maximum setback of 150 feet (45.7 m). Average lot depth (ALD) is determined by averaging the length of the left, center, and right linear property lines of a parcel based on a horizontal plane (plat map). The Commission reasoned that larger setbacks were warranted if a property owner had room to build inland and out of harm's way. Furthermore, such a policy would allow traditional post and pier buildings to be incrementally relocated inland over time in response to chronic erosion. For most lots, the ALD formula equates to 25% of the sum of the center and side property lines divided by three.

3.2. Shortcomings of a standardized setback policy

Shoreline setbacks are intended to reduce risks to structures from coastal hazards, protect shoreline access, and conserve beach and sand resources (MPC, 2003). Many municipalities use a one-size-fits-all approach to regulate oceanfront development by restricting construction to pre-set distances from the shoreline (Genz, 2006). In Maui's case, this policy created a uniform setback based on a property's size rather than based on the site's substrate or dynamics of the shoreline's movement over time. The policy is premised on coastlines reacting similarly to coastal hazards and that individual landowners should have similar and consistent development rights and expectations. Maui's ALD policy recognizes that buildings should be constructed further inland when there is room to move away from the ocean. The ALD policy incorporates the idea of managed retreat where traditionally existing post and pier houses and other structures can be moved out of harm's way as coastal hazards threaten oceanfront property and shorelines retreat. But this strategy is flawed. In years past, most homes in Hawaii were built during the agricultural plantation era using wood-frame, post and pier construction that would be elevated above coastal hazards or could be easily relocated inland. However, elevation does nothing to retard erosion and the shoreline would continue to move landward if shoreline armoring isn't built (Heinz, 2000). Furthermore, to accommodate larger homes, slab-on-grade building construction is more prevalent today, which makes it impossible to move or relocate the home when threatened by coastal erosion.

3.3. Shoreline retreat

Maui experiences more beach erosion than Kauai or Oahu Islands, with 85% of the beaches erosional, including 11% lost, and an average change rate of −0.56 feet/year (−0.17 ± 0.01 m/y) (Fletcher et al., 2003, 2012). Within the last century, 4.2 miles (6.76 km) of beach have been lost of Maui's 33 miles (54 km) of sandy shorelines along its 120 miles (193 km) of coastline (CGC, 2011; Fletcher et al., 2003). Moreover, 70% of beaches on Maui have narrowed or been completely lost, threatening tourism and destination development (Fletcher et al., 2012). Eighty-five percent exhibit long-term erosion trends, whereas 76% reflect more recent (decadal) trends in erosion (ibid.). Unfortunately, beaches are being lost on every island due to the construction of seawalls and overdevelopment along the coastline (Fletcher et al., 2011).

Maui's past coastal permitting and site development practices did not account for site substrate, structural design, construction material, shoreline erosion rates, or a structure's proximity to the shoreline. Maui's lot depth shoreline setback policy resulted in many buildings being constructed only 20, 25 or 40 feet (6.1, 7.6 or 12.2 m) from the shoreline.

In response to coastal storm events and severe erosion during the 1990s, a substantial amount of shoreline hardening took place as emergency protection of legally habitable structures (Fletcher et al., 2011). County approval of shoreline hardening by individual property owners led to down drift scouring, depletion of sand reservoirs, and interruptions in littoral cell transport processes. These erosion responses were not coordinated and were requested on a property-by-property basis. This resulted in a variety of types of hardening including un-engineered rock piles, rock revetments, geo-textile sand bags, seawalls, and groins, each with their own coastal resource impact, proliferated along Maui's pristine beaches. Inappropriate responses to site-specific erosion have impaired the public's shoreline assets by reducing lateral access and interrupting sand transport processes (Norcross-Nu'u and Abbott, 2008). This has led to smaller and narrower beaches on retreating shorelines because erosion is accelerated when sand is lost from the littoral system either by impoundment or by interruptions in sediment delivery to the beach (ibid). As a result, Maui's beaches have narrowed an average of 70% in front of shoreline hardening (Fletcher et al., 2012). A 2003 shoreline hardening inventory identified 371 structures, such as seawalls, revetments and geo-textile sand bags, along 54 miles (87 km) of shoreline, 66% of which have negatively affected sand transport and/or public shoreline access (Feindel, 2003).

Worldwide, the adverse effects of inappropriate shoreline hardening and their interruptions to a beaches sediment budget are well documented (NRC, 1995). Research in Italy found that most of the investigated beaches experienced progressive erosion because of sediments were being trapped by human structures resulting in the formation of wide beaches on the up-drift side and erosion down-drift (Martínez del Pozo and Anfuso, 2008). In the United Kingdom, construction of seawalls has exacerbated coastal erosion among popular tourist beaches (Cooper and Pethick, 2005). Shoreline hardening has proliferated along Puget Sound over the past 45 years with negative effects to neighboring property and shoreline access (Gabriela and Terichb, 2005). In all these cases, an initial building setback that accounted for coastal erosion and a building's lifespan would probably have avoided the need to armoring the shoreline and its adverse impacts on adjacent beaches.

3.4. Planned avoidance of erosion prone areas

In 2003, the Commission augmented the ALD policy by adopting site-specific annual erosion hazard rate (AEHR) shoreline setbacks. Both the AEHR and ALD policies pertain today (MPC, 2003). Locating inland based on projections of shoreline erosion seeks to avoid coastal hazards and reduces the need to harden the shoreline in response to site erosion. Sandy beaches serve as natural buffers dissipating wave energy and mitigating the potentially damaging effects of coastal hazards. Based on site-specific erosion data, site configuration, and lot-depth, the Department calculates (or verifies calculations) as to where buildings should be constructed to avoid erosion prone areas and assist landowners in developing their property in balance with nature. To recap, hardening property on sandy shorelines defeats the purpose and intent of living next the beach.

3.5. Educating and outreach

In a destination development economy, having a strategy to communicate the hazards and risks of oceanfront development is imperative (Drejza et al., 2011). Educating oceanfront property owners of the value of avoiding coastal through shoreline setbacks is critical to the success of the coastal permitting regime. Many new owners, particularly from the continental US, are unfamiliar with the ferocity of the Pacific Ocean. To improve awareness, the Department created an educational website, revised its permit applications, and distributes brochures which illustrate the purpose, and outcomes, of implementing adequate shoreline setbacks. Sea Grant developed a Beach Management Plan (Norcross-Nu'u and Abbott, 2008), published Natural Hazard Considerations for Purchasing Coastal Real Estate in Hawaii (Eversole and Norcross-Nu'u, 2006), Homeowner's Handbook to Prepare for Natural Hazards (Hwang and Okimoto, 2011). The state Office of Planning distributes a Special Management Area Guidebook (DBEDT, 2006a) and the Hawaii Ocean Resources Management Plan (DBEDT, 2006b), which explain Hawaii's coastal permitting regime and draw on innovative coastal management strategies respectively. The Department holds multi-agency hazard avoidance workshops for the public and meets with stakeholders that serve as intermediaries in oceanfront development. The Realtors' Association, building and contractors union's, aggregate dealers, and coastal engineering firms should also be apprised of the risks of shoreline development and the processes for obtaining approvals. The synergy created by outreach and increased stakeholder awareness can lead to improved program effectiveness, reduce the number of buildings at risk from coastal hazards, and help protect beaches and shoreline access.

4. Methodology – moving to place-based shoreline setbacks

Several factors should be considered when determining methods to delineate the shoreline setback area for oceanfront development and new building construction. First, establish a method to estimate site-specific erosion potential. Second, develop a formula to calculate how far the setback line should extend inland. Third, create a clear method to delineate the width and depth of the shoreline setback area. Finally, the setback area should be off limits to building construction given its potential for exposure to coastal hazards, except for very unusual unforeseen circumstances.

4.1. Estimating site-specific erosion potential

Fletcher (2003) and Fletcher et al. (2003) developed statistically valid methodologies that accurately estimate rates of annual erosion hazards specific to Hawaii (Genz et al., 2007). Unlike the continental US, Hawaii's beaches tend to be small, pocket beaches where littoral dynamics occur on a fine scale (i.e., <1 mile, 1.6 km). Trends in long-term (early 1900s–present) and short-term (mid-1940s–present) shoreline change were calculated along the Maui's shores. Annual erosion at single transects spaced at 66 feet (20 m) intervals was calculated using liner regression (LR) and reweighted least squares. The LR method is preferable if both uncertainties and storm shorelines are not known (Genz et al., 2009; Romine et al., 2009). However, the method tends to over fit data by using more parameters than necessary because it assumes that both signal and noise at adjacent transects are independent (Frazer et al., 2009). By comparison, using a polynomial model to capture alongshore variation in the erosion rates allows for acceleration in erosion since the rates vary with time. The polynomial method more accurately predicts long-term (50 year) future shoreline positions (Romine et al., 2009), whereas the linear regression method predicts short-term (5–9 year) positions better (Genz et al., 2009). Neither method captures episodic erosion events or variations between winter and summer seasons due to the long-term nature of the data set. Past sea level rise is captured, but neither method accommodates for accelerated sea level rise in the future.

4.2. Calculating the shoreline setback line

The shoreline setback line represents the distance that the shoreline is projected to retreat inland during a building's lifespan. The line is delineated on a horizontal plane irrespective of topography in order to match two-dimensional site, plat and building plans. To calculate the setback, the annual erosion hazard rate (AEHR) for the property is multiplied by 50 years and a 25 feet (7.6 m) buffer is added. The formula for each specific transect is the AEHR in feet/year × 50 years + 25 feet = setback. The 50-year multiplier reflects the minimum expected lifespan for a wood-frame house (Hwang, 2005; FEMA, 2000). The additional buffer compensates for variability in the erosion rate data, high surf, episodic storm events, and the risk of sea level rise. In Kauai, recent shoreline setback rules use a 70-year multiplier and 40 feet storm buffer to reflect the average lifespan of a coastal building (O'Connell et al., 2010). The area located between the state-certified shoreline and the setback line, bounded by the property's side yard boundaries, forms the shoreline setback area (CZMA, 1997; MPC, 2003).

5. Results

5.1. Complexities in calculating the setback line

The shoreline setback rules adopted in 2003 had several shortcomings when calculating or delineating the correct setback. First, the AEHR setback only applied to properties abutting the shoreline (i.e. actually touching the ocean). Some private properties are separated from the ocean by a government beach reserve, while others have easements for utilities, view planes, roads, or infrastructure between their property and the ocean. In some cases these areas have narrowed from erosion to the point that high surf regularly inundates the inland private property. Yet the government beach reserve (or easement) is technically the property abutting the shoreline. If AEHR setbacks applied only to those properties abutting the shoreline, then only those properties that have experienced erosion would be subject to the AEHR setback formula. Amendments removed the abutting term because the term contravenes the intent of the rules, which is to prevent construction in areas that *will likely be* eroded within 50 years. Setback rules now apply to all properties within 150 feet (45.7 m) of the shoreline, regardless of whether the property abuts the shoreline or is separated from the ocean by some form of jurisdictional buffer.

Second, the rules stated that the *greater* of the shoreline setback lines, as calculated using the AEHR method and the ALD method shall form the shoreline setback line. But it is possible that both AEHR and ALD setback lines are of equal distance from the ocean. In some cases the calculated setback lines intersect with one another and determining which setback is "greater" can be difficult.

Third, the ALD method is problematic for lots that have eroded and now have lot lines that extend into the ocean. In Hawaii, submerged lands revert to the state's jurisdiction. But the county uses the lot on record (i.e. deed) for zoning, subdivision, and taxation purposes until the landowner formally conveys areas underwater to the state. Confusion ensued as to whether to use deeded lot or un-submerged land area as the basis for the ALD calculation. Moreover, the ALD setback is measured from, and runs parallel to, the shoreline. But parallel means two lines that are drawn laterally to each other, as well as two lines that are perpendicular to one another. A new building proposed at 726 South Kihei Road, Maui illustrates this challenge (Fig. 1). On a convex or curvy shoreline, this can result in two ALD setback lines with neither necessarily being "greater" than the other.

Fourth, many sites have more than one AEHR measurement, given that transects are spaced 66 feet (20 m) apart on the erosion rate maps (Fig. 2). The rules did not specify whether only transects on the subject property or neighboring properties are to be considered. Since the state-certified shoreline is the baseline from which the setback line is calculated, some landowners claimed they couldn't measure the shoreline on adjacent privately owned lands. However, in most cases a surveyor can estimate the adjacent shoreline and transect locations. Now the amended rules specify that the AEHR setback line should be calculated and plotted at each measurements location (i.e. 20 m intervals) including neighboring or adjacent transects. The plotted points are then connected across the subject parcel to form the AEHR setback line. This ensures that erosion at neighboring sites is considered when determining a safe location for building construction.

Fifth, if a site's established erosion rate is zero, the AEHR setback formula is 50 years × 0 feet/year + 20 feet buffer suggesting a 20 feet (6.1 m) setback. Yet the county's minimum ALD setback is 25 feet (7.6 m). While 25 feet (7.6 m) is the correct setback, the difference confused the public and resulted in erroneous site plans. The amendments increased the AEHR buffer from 20 feet to 25 feet (6.1–7.6 m) to ensure the proper minimum setback. Both the ALD and AEHR setback calculations must be shown, both setback lines drawn on site plans, and the more landward of the two lines (or the more landward segments of each line if they intersect), forms the final shoreline setback line (Fig. 3). The Shoreline Setback Area (SSA) begins at the state-certified shoreline, is bounded on its sides by the parcel's un-submerged property lines, and extends inland to the final, most conservative shoreline setback line.

5.2. Irregularly shaped parcels

Determining the ALD shoreline setback line can be difficult for parcels that are not rectangular (Norcross-Nu'u and Abbott, 2005). The setback formula is problematic for parcels bounded by the sea on more than one side. Fig. 4 depicts a peninsula or spit at 175

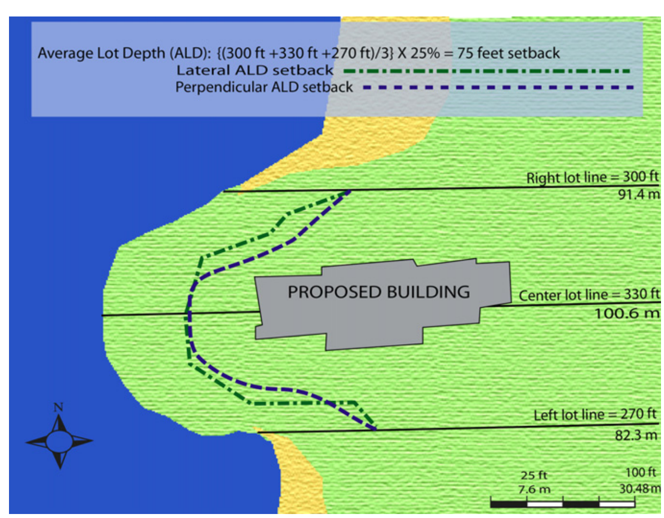

Fig. 1. Demarcation of setback based on lot depth.

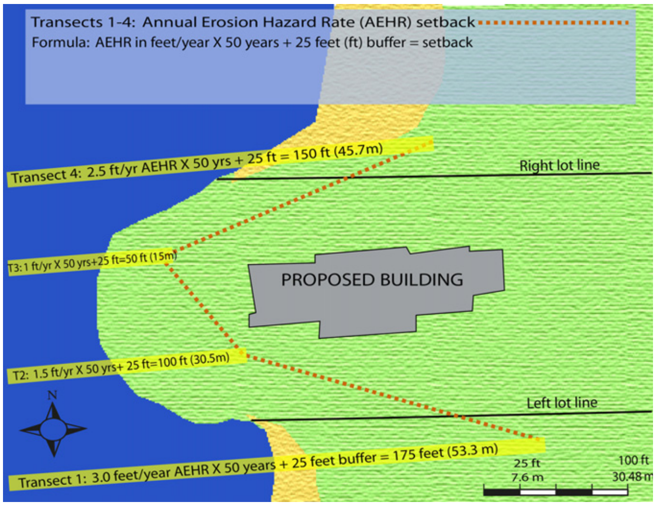

Fig. 2. Demarcation of the shoreline setback based on erosion.

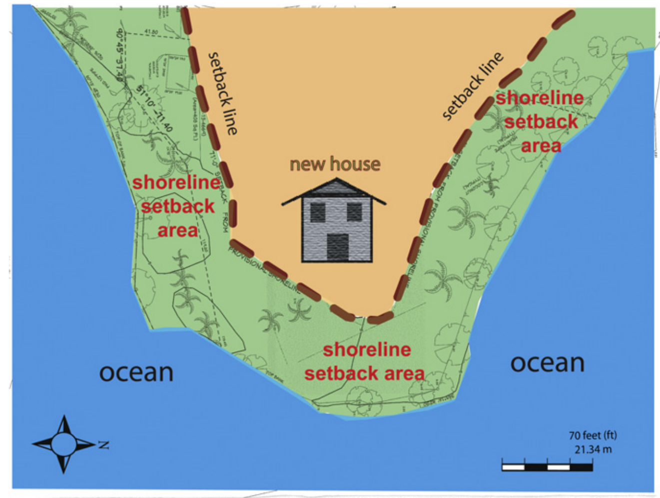

Fig. 4. Shoreline setback on a peninsula.

Haneoo Road, Hana adjacent to Koki Beach Park, Maui where calculating the ALD was challenging. Similarly, setback formulas fare poorly for parcels that only have a small portion abutting the shoreline such as “L” or “flag lots”. Fig. 5 illustrates two adjacent lots at 4851 and 4855 Lower Honoapiilani Road, Lahaina in West Maui. The two parcels have equivalent lot depths and thus equivalent ALD setback distances. But each properties exposure to coastal hazards differs substantially. Property “A” could build outside of the setback area as marked, yet the structure would be at risk of inundation from waves that cross Property “B”. Over time, the shoreline may retreat across Property “B” into Property “A”, thereby mitigating the effectiveness of the setback. To address these challenges, the Commission granted the Director discretionary authority in determining the setback on irregularly shaped lots. The determination is reported to the Commission for transparency to the public and to ensure compliance with the intent of the rules.

5.3. Setbacks on cliffs and bluffs

Many of Maui’s shorelines consist of clay banks or volcanic bluffs. These may erode rapidly or slump unexpectedly due to soils being saturated with water from over-irrigation, sumps, poorly designed drainage, heavy rainfall or the pounding of large surf from storm waves. In some cases, beach replenishment could help reduce cliff erosion and collapse, a management technique that has been successful in Portugal (Cruz de Oliveira et al., 2008). Where bluffs rise gradually from the ocean, a survey may determine the shoreline’s location, but not a safe distance for construction and site development given the sheerness of the site’s topography. Delineating the shoreline may be dangerous and even impossible in locations with sheer cliffs, rocky overhangs, sea caves and eroding clay banks or bluffs. Yet, the state-certified shoreline serves as the

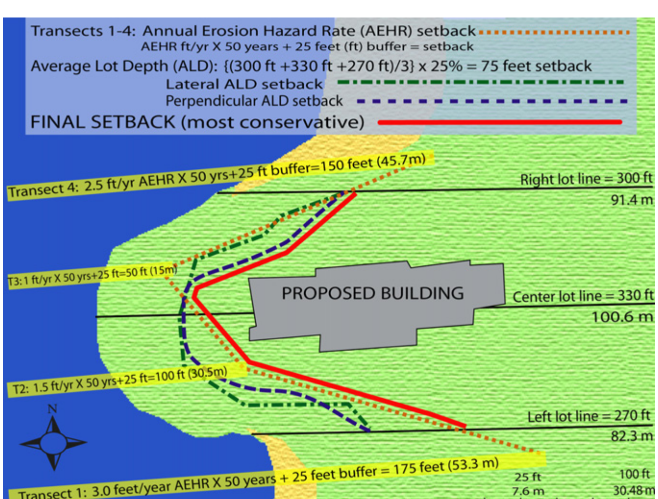

Fig. 3. Correct shoreline setback demarcation.

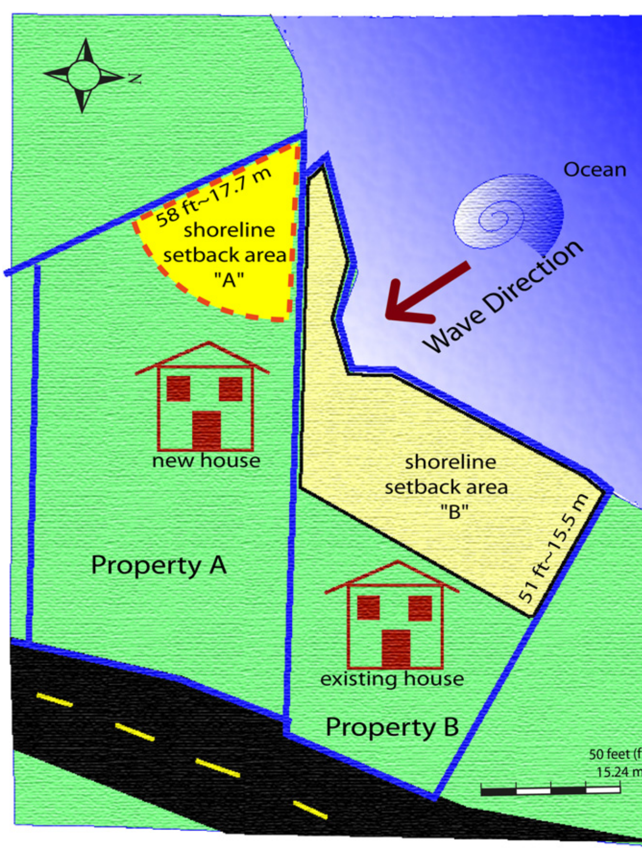

Fig. 5. Shoreline setback on an irregularly shaped lot.

baseline from which the setback is measured making the setback area demarcation difficult.

Catastrophic cliff failures during an October 2007 earthquake led to road closures and property damage along the shoreline in east Maui. In December 2007, a torrential rainstorm combined with high surf caused a catastrophic cliff failure at 11 Hale Malia Place, West Maui placing a home in jeopardy (Fig. 6). In these circumstances, the original setback determination should have accounted for the stability of the bluff, long-term bluff retreat, uncertainty in the analysis and building lifespan (Johnsson, 2005). But the 2003 setback rules lack a formula to estimate cliff or bluff erosion (Norcross-Nu'u and Abbott, 2005).

In 2006, the Commission granted the Director discretion in determining the setback for sites with steep banks, ocean side cliffs or seaside bluffs. The Director may also waive the state-certified shoreline survey in situations where safety is of concern. Both are reported to the Commission to ensure transparency in decision-making.

6. Discussion

Managed retreat from the shoreline can be an effective strategy to adapt to sea level rise and eroding coastlines. To enact such a strategy, careful thought and consideration should be given to the possible permutations and misinterpretations of the rules and regulations used to implement the policy. Providing decision makers with discretionary authority is indispensable when addressing unusual and unforeseen circumstances. However, these decisions must be transparent to the public, elsewise the intent of the policy risks manipulation by political actors and development interests. These risks are particularly keen in a destination economy where the priorities of leaders, particularly if elected, can rapidly shift from protection of natural beach assets for long-term community benefit to capitalizing on these assets for short-term economic gain and the creation of construction, resort and tourism jobs.

Locating inland of areas prone to erosion and/or flooding is common sense. Translating this simple idea into a set of precautionary planning rules and enforceable regulations can be difficult. Diagrams, pictures and locally relevant examples can be very instrumental in conveying the intent and applicability of shoreline setback rules. Conducting a flow chart analysis of the setback determination process can expose gaps in logic or situations unconsidered. Peer review of proposed rules by persons with historic knowledge of the coastline's dynamics and a strong sense of place helps capture the unique features of a particular coastal community. This empirical knowledge should be combined with sound science and good judgment to tailor setback regulations to reflect local situations and coastal dynamics, while being careful to not diminish the need to build out of harm's way. As presented here, determining the setback for irregularly shaped property or sites with cliffs or bluffs can be challenging without knowledge of local coastal dynamics, weather patterns, and hazard exposure. Even with sound science, overlaying predicted erosion zones or hot spots onto building site plans can present challenges of interpretation that delay rational, prudent development.

Fig. 6. Setbacks must account for catastrophic cliff failure.

Having sound policy based on good science avoids the dilemma of government officials having to weigh an individual landowners right to protect their dream home or building against the public's right to coastal recreation, access and sandy beaches. Such policy also prevents individual property owners from taking actions, such as armoring the shoreline, that are detrimental to the community and the destination at large. Properly located oceanfront buildings, designed in balance with nature and the structure's obsolescence, can derive benefits, both short and long-term, for the coastal community and the private landowner.

7. Lessons learned

The English language is messy. Practitioners should take great care to have their ideas for regulatory guidance peer-reviewed by individuals outside of their jurisdiction and field. Listed below are a few lessons learned from Maui's experience in implementing place-based setbacks for oceanfront construction.

1. State the purpose of the policy and frame the issue at hand necessitating the policy. Clearly and concisely states the policy's intent and objectives, preferably with measurable benchmarks.
2. Policy content and key phrases should have several peer-reviews by laymen and individuals familiar with the locality, not only lawyers and policy analysts. The use of a thesaurus can help reduce misinterpretations of key words and phrases.
3. Administration of the policy should be tested through flowchart and framework analysis to ensure consistency in determinations, expose gaps in logic, and capture potential unaddressed circumstances.
4. Adding diagrams and locally relevant pictures to regulations is a very effective means of demonstrating a policy's intent and how it is to be applied.
5. To be effective, precautionary rules must have strong enforcement, stiff penalties for non-compliance, and the ability to remove unauthorized structures where appropriate.
6. Shoreline setback policies should incorporate incentive mechanisms to avoid coastal hazards and preserve publicly valued amenities. Incentives are more effective over the long-term than relying on government intervention.
7. Providing discretionary authority is essential to address unforeseen circumstances that invariably arise. Guidance based on unambiguous evaluative criteria and requiring accountability through public reporting mechanisms are critical where politics and power can influence discretionary decision-making.
8. Practitioners should distinguish between planning and permitting. Permitting enacts existing laws. *Planning* contemplates the future to reduce adverse impacts of land use, conserve valued resources, and increase options for sustainability.
9. Practitioners should effectively plan for the future by creating policy that withstands shifts in political will over time. Such policies use good science, contain evaluative criteria,

incorporate cogent analysis by discretionary authorities, and offer decisions that are transparent and reported to the public.

10. Foresight and sound science based policy help sustain destination development economies, minimize risks to structures and people from coastal hazards, and preserve valuable environmental assets and amenities. These amenities helped create interest in the location, thereby creating a destination and its development potential. Prudent planning can help ensure the destination retains its value for marketability, future development and continued economic vitality while retaining its coastal amenities.

8. Conclusion

Retaining valuable beach and sand resources, protecting lateral access along the shoreline, and reducing the risk of building failure or damage from coastal hazards creates long-term benefits for destination coastal development communities. Implementing site-specific shoreline setbacks for the construction of new buildings and creating incentives for managed retreat from areas prone to erosion and flooding are excellent mechanisms to sustain beach amenities and retain the destination's economic viability.

A properly located building, whose location is determined scientifically, is more likely to be protected from coastal hazards and therefore retain its value and function over time. Locating structures out of harm's way ensures that the coastal amenities that created a site's value, such as healthy sandy beaches, are preserved and public benefits endure. Maui County made a concerted effort to market its environmental assets, beaches chief among them. With the enactment and implementation of site-specific erosion-based shoreline setbacks, Maui has signaled a desire to sustain the island's development economy, while protecting beach and public resources. Beautiful, accessible shoreline resources and ease of access to ocean waters for recreation contribute to the value of oceanfront property and the economic vitality of a destination. Thus, by protecting the beach, one can preserve assets for today and the future, and simultaneously offer the children of tomorrow an attractive, safe place to build their own castles near the sand.

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