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Conclusion

Collaboration: Sea-level Marin Adaptation Response Team's (C-SMART) sea level rise vulnerability assessment examined the exposure, sensitivity and adaptive capacity of built and natural assets. Many of Marin's essential and beloved coastal community assets are vulnerable to sea level rise.

Flooding from sea level rise could reduce useable living space, adversely affect tourism, transportation, and natural attractions and resources, and impact roughly 1,400 properties, 1,100 buildings, 3,000 residents, hundreds of employees, and several million visitors; yielding significant economic impacts locally and beyond. Minor storm impacts alone could account for $17,357,000 in property damages (the 2014 market value of 8 median Stinson Beach homes) if all 1,100 homes sustained minor damage (not exceeding $17,000 per building). The assessed value alone (typically less than the market value) of the exposed properties reaches nearly $300 million. Moreover, these physical and economic impacts will be felt differently across these communities and the various income and age groups causing potential social and economic inequities.

In the coastal zone, 15 percent of buildings are vulnerable at the low end of the long-term scenario (scenario 4 – 40-inches of sea level rise and 100-year storm), and 20 percent of buildings are vulnerable at the high end of the long-term scenario (scenario 5 – 80-inches of sea level rise and 100-year storm). These buildings are concentrated in the Calles and Patios neighborhoods, Downtown Bolinas, and the Tomales Bay shorelines in Inverness and the East Shore (Marshall) community. On the East Shore, 90 to 100 percent of commercial, and 78 to 84 percent of residential parcels are vulnerable in the medium-term scenario and high end of the long-term scenario, respectively—the majority of buildings along the eastern shore of Tomales Bay. In Bolinas, 27 to 87 percent of resident and visitor serving commercial buildings are vulnerable in the medium-term and long-term (high estimate), respectively. In Stinson Beach, nearly 70 percent of residential parcels— and nearly 100 percent of the parcels west of Shoreline Highway are vulnerable to sea level rise and storms by the medium-term scenario.

Additionally, up to twenty miles of public and private roadways could be compromised. Roadways exposed in the short-term include Shoreline Highway between Bolinas and Stinson (20 percent compromised in Coastal Zone), Calle Del Arroyo, all private calles and patios streets, Wharf Road, and several creek crossings and bridges. Other low-lying portions of Shoreline Highway, several local roads, and Sir Francis Drake Boulevard (17 percent compromised) are vulnerable in long-term.

Coastal communities also depend on septic systems (Stinson Beach, East Shore), water supply systems (Stinson Beach, Inverness, Pt. Reyes Station, Dillon Beach), and shared septic systems (Dillon Beach). In addition to exposed buildings, road and utility systems are the most vulnerable assets. Unlike buildings; however, roadways and utilities are lynch pin assets, such that their malfunction or destruction will have negative ripple effects on nearly all other assets. More specifically, OWTSs for many exposed buildings (except in Bolinas), private wells on the East Shore, water distribution pipes in Stinson and Inverness, a creek side well and bluff top Oceana Marin sewage lift station in Dillon Beach, and the sewage lift station in Downtown Bolinas could be vulnerable to sea level rise and storms.

The most vulnerable assets (in order of timing and flood depth) of coastal Marin are:

- Near-term (Scenarios 1 and 2)
    - Beaches, underground on-site wastewater treatment systems (OWTS), buildings, and streets in Stinson Beach west of Shoreline Highway.
    - Shoreline Highway between Stinson Beach and Bolinas, at Green Bridge in Point Reyes Station, the Walker Creek crossing in Marshall, and bridges on Middle Road and Valley Ford Lincoln School Road in the near-term.
    - Beaches, beach front and downtown buildings and streets in Bolinas.
    - Septic systems, beaches, marshes, and buildings along the eastern and western

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  shores of Tomales bay on the East Shore and in Inverness.
  - Water distribution pipe extending underneath Shoreline Highway and Sir Francis Drake serving Inverness residents.
  - Intertidal rocky lands in Muir Beach and Agate Beach (Duxbury Reef).
  - Fire service facilities and tsunami routes in Stinson Beach.
  - Recreational facilities at Dillon Beach Resort and Lawson's Landing.
  - Bluff top buildings in Muir Beach, Bolinas, and Dillon Beach may be vulnerable to accelerated erosion.
- Medium-term (Scenario 3)
  - Olema-Bolinas Road, the only access road to Bolinas.
  - Further north into downtown Bolinas, including the historic district.
  - Bolinas Public Utilities District lift station.
  - Shoreline Highway in Pt. Reyes Station Sir Francis Drake Blvd. in Inverness.
- Long-term (Scenarios 4 and 5)
  - Shoreline Highway along the East Shore in the medium and long-terms.
  - Buildings in Inverness west of Sir Francis Drake Blvd.
  - Downtown Bolinas up to Bridgton Road along Olema-Bolinas Road, including the market, library, community center, gas station, museum, and several other valued places.

Table 85. Coastal Marin Vulnerable Assets

	Short-term	**Medium-term**	**Long-term Low End**	**Long-term High End**
Muir Beach	• Bluff-top buildings			• Pacific Way • Emergency Green Gulch Access
	• Green Gulch Creek • Redwood Creek			
Stinson Beach	• Septic systems west of Shoreline Highway • Water Distribution Lines • Calle del Arroyo • Upton Beach • Patios and Calles Buildings • Shoreline Hwy • Water District Office • Walla Vista Walkway	• Stinson Fire Department #2		• CA Coastal Trail
	• Easkoot Creek			
Bolinas	• Bluff-top buildings • Tsunami Evacuation Route • Brighton Beach • Downtown	• Sewage Lift Station • Olema-Bolinas Road • Bolinas Super Market	• Bolinas Library • Bo-Gas Station • Gospel Flats • Community Center	• Calvary Presbyterian Church • Bob Stewart Trail • Bolinas People's Store

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	Short-term	Medium-term	Long-term Low End	Long-term High End
	Buildings • Wharf Road • Agate Beach • Historic District		Emergency Shelter • Community Land Trust Housing	• Bolinas Post Office • Bolinas Stinson School
	• Bolinas Lagoon • Pine Gulch Creek			
Inverness	• NMWD Pipeline • Inverness Yacht Club • Brock Schreiber Boathouse • Shoreline Buildings • Martinelli Park • Chicken Ranch Beach	• Sir Francis Drake Blvd. • Inverness Store	• Dana Marsh & Beach Access • Motel Inverness • Historic District • Shell Beach Tomales Bay State Park	• Tomales Bay Resort • Inverness Post Office
	• Tomales Bay			
Pt. Reyes Station	• NMWD Pipeline • Green Bridge	• White House Pool and Trail • Shoreline Hwy		• Gallagher Well • Olema Marsh Trail • Buildings along Lagunitas Creek
	• Lagunitas Creek			
East Shore	• Walker Creek Access Point • Livermore Marsh Cypress Grove • Hog Island Oyster • Shoreline Buildings • Shoreline Hwy • Marconi Boat Launch • Tony's Restaurant • Tomales Bay Oyster Company	• Inn on Tomales Bay	• Nick's Cove • Millerton Point • Historic District	• Shoreline Hwy
	• Tomales Bay • Keys Creek & Fishing Area			
Dillon Beach	• Bluff-top buildings • Lawson's Landing Facilities	• Sewage Pump Station	• Dillon Beach Resort Parking Lot	

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	Short-term	Medium-term	Long-term Low End	Long-term High End
	• Estero Americano			

Source: OCOF, Marin Map

Built and natural features in Table 85 will be addressed in the adaptation planning phase following this assessment. Some communities are already adapting to sea level rise. Some efforts occurred recently to decrease vulnerability to flooding in West Marin. The recent Redwood Creek restoration at Muir Beach accounted for sea level rise in the project design, with room for the beach and tidal lagoon to migrate landward, and the parking lot reconfigured away from direct wave action to offset storm surge impacts. Residents note that wetland restoration near Point Reyes Station seems to have reduced flood impacts to roads. At Overlook Drive in Bolinas, the bluff collapsed and dropped roughly 50 feet, taking the road and water pipes with it. The water pipes were rerouted behind homes landward of the new road in a $1.5 million County-funded bluff stabilization project. BPUD elevated the water lines at "Surfer's Overlook" for roughly $500,000 and anticipates that moving the sewer lines will cost an additional $300,000-400,000. Finally, collaborative efforts of about 20 property owners paid $1.5 million to relocate their bay side septic leach lines to the east side of Shoreline Highway and away from Tomales Bay in Marshall.

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Implementing additional adaptation measures may require new institutional, legal, and financing arrangements, engineering measures, and other incremental actions property owners can take. These measures and sea levels on the coast must be monitored and evaluated to inform need and effectiveness of these types of strategies. This vulnerability assessment lays the informational foundation for adaptation planning and implementing the necessary measures to protect, accommodate, retreat, or preserve (natural areas). The adaptation planning phase following this assessment will explore and provide sea level rise and storm adaptation options for communities, residents, and visitors of coastal Marin.

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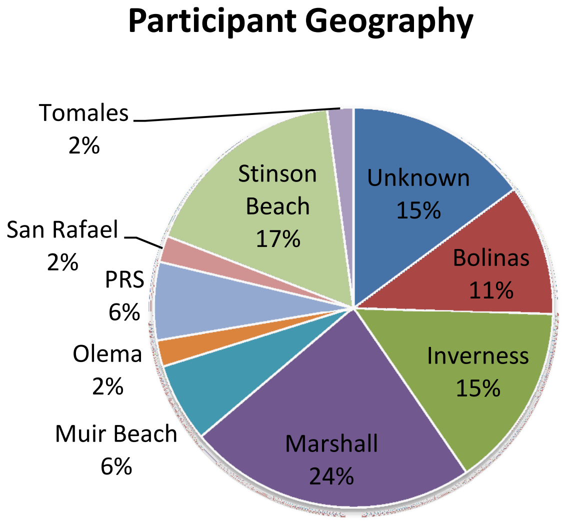
APPENDIX A

Appendix A: Community Workshop Results

The Marin County Community Development Agency (CDA) convened three community workshops on October 28, 29, and 30, 2014 (in Inverness, Stinson Beach, and Tomales respectively) as part of the Collaboration: Sea-level Marin Adaptation Response Team (C-SMART) program. As the second round of C-SMART Public Outreach meetings, these workshops built upon the kick-off and presented additional sea level rise background information to participants. Participants also engaged in discussions on ecological and cultural assets that could be exposed to rising waters and storm surges in the future, and potential local vulnerabilities and adaptation measures. Specifically these workshops included: (1) “what we love” photo boards, (2) a presentation on sea level rise science, (3) exposed asset identification mapping, and (4) a vulnerabilities discussion. The complete agenda is included at the end of this appendix.

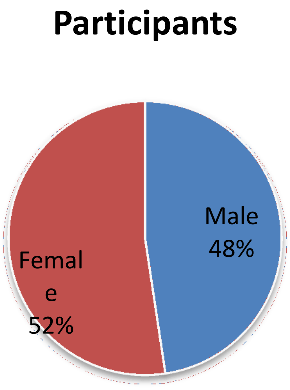
Publicity
The public meetings were promoted extensively, including an announcement on the C-SMART website (www.marinslr.org), distribution via a listserv of 4,000 people, posting fliers at various bulletin boards around the coast, a West Marin County Radio Announcement, a press release, and ads placed in the West Marin Citizen and Point Reyes Lighthouse. Members of the C-SMART Stakeholder Advisory Committee (SAC) also helped spread the word through local community networks and organizations.

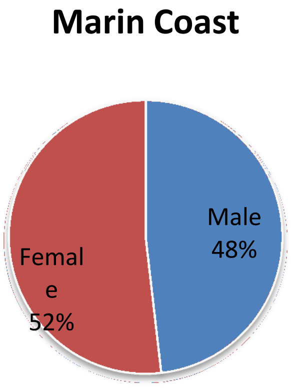


Participant Context
To determine if the people who attended the community meetings were representative of the communities they live in, we asked willing participants to answer several demographic questions. These figures were compared to 2012 American Community Survey figures for the Stinson Beach, Muir Beach, Bolinas, Dillon Beach, Inverness, and Point Reyes Station Census-designated Places (CDPs). Note that the participants do not represent a statistically valid sample.

Of the 66 participants who responded, the greatest geographic representation was from Marshall (25%), followed by Stinson Beach (17%), and Inverness (15%). Relative to the comparative population sizes, Point Reyes Station was significantly underrepresented while Marshall was well represented.

APPENDIX A

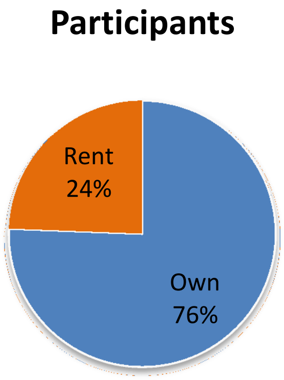


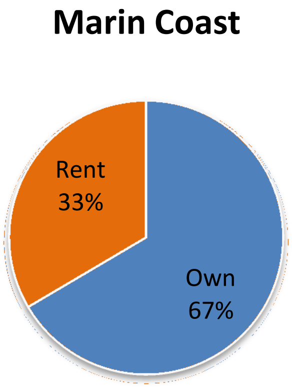


Representation amongst the 66 participants for housing type was 76% owner-occupied housing, and about 24% renter-occupied housing. Compared to the ACS owner to renter figures in this region, home owners were slightly more represented than renters. Of the participants, approximately 9 stated they owned a property or business.

The group was relatively gender balanced with 52% female and 48% male. Compared to ACS data for the region, this is right on track with community-wide figures.

Community representation was not well achieved with respect to age groups, with nearly 95% 45 years of age or older, with 52% were 65 years of age or older. Only 7% were between 25-44, while persons under 25 were not represented. Compared to the Marin Coast region, those age 65-74 were over represented, where as persons 45-64 years old were alinged with community representation.





With respect to race and ethnicity, the large majority of particpants classified themselves as White at 93%, slightly over the regional figure of 83% White. Asians were represented on par with regional statistics, Latinos were underrepresented, and Blacks/African Americans were not represented at all.

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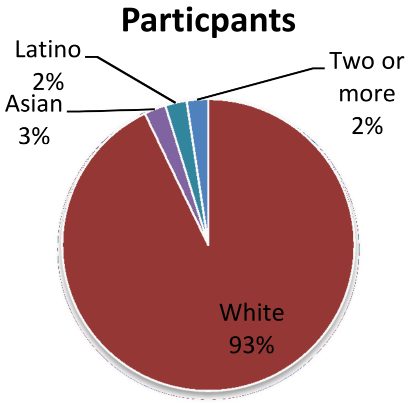

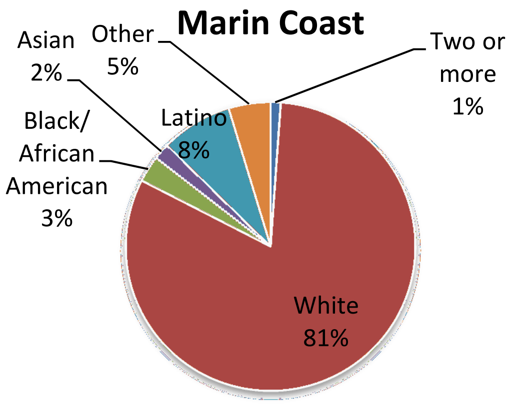

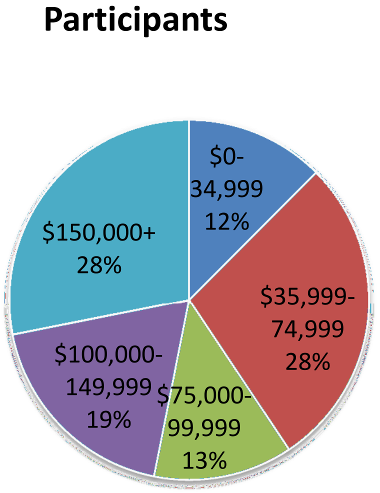

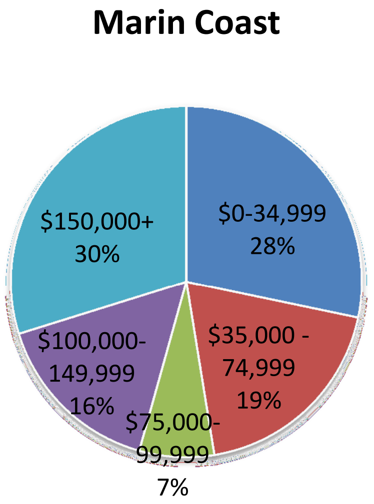

The last demographic questions participants answered pertained to household income. Of those responding to the question, the largest representations were in the $35,000-74,000 and $150,000+ income brackets. Compared to regional figures, participants with household incomes $35,000 and below were underrepresented at about 12%, compared to 28%. The $75,000-99,999 income group was overrepresented relative to the regional figures for that income level.

Participatory Meeting Activities

"What We Love" boards were created to solicit local input on what makes the Marin Coastline a unique and special place to live, work, visit and experience. Four thematic boards were developed covering the following elements: natural environment and agriculture, community and built environment, scenery and recreation, and public services and infrastructure. In advance of the meeting, participants were invited to bring in photos of what makes the Marin coastline a special place to them, and at the meeting they were invited to place the photos on the board, and/or provide written responses articulating what they value. Reponses included the local flora and fauna, ranches, a variety of recreational activities, public lands, public faciltiies (schools, post offices, libraries, clinics, etc.), restraurants, cafes, and more.

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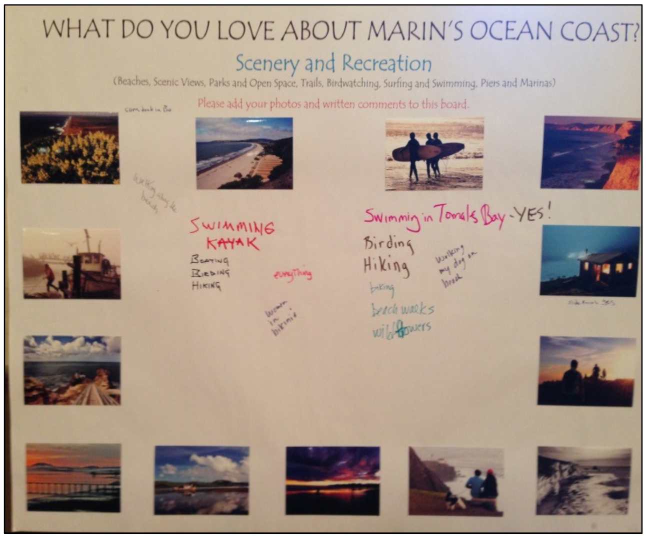

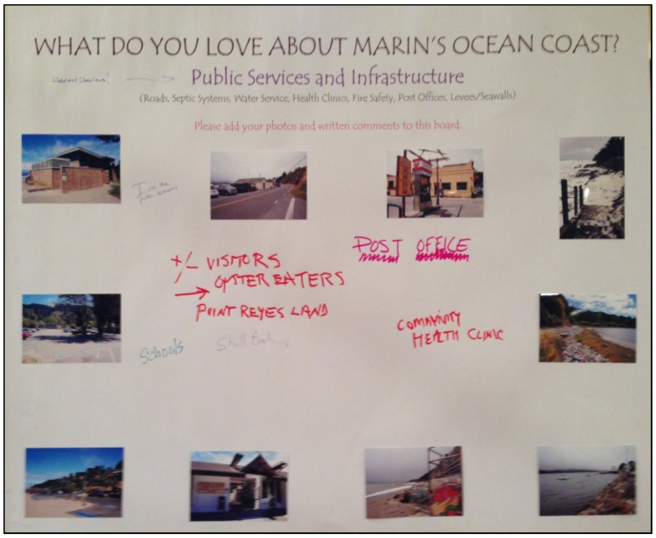

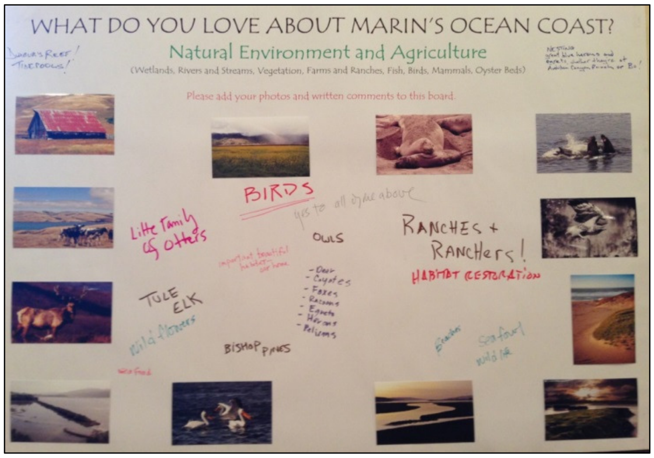

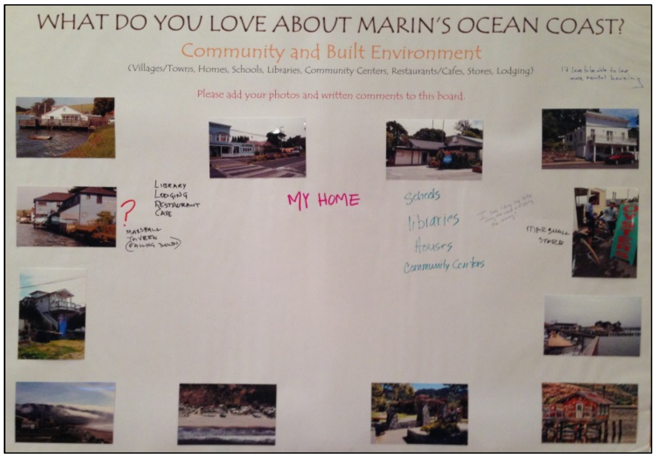

Participatory Asset Mapping

In advance of the Meeting, CDA staff utilized Geographical Information System Technologies to draft large maps depicting coastal assets that may be exposed to increased sea levels and intensified storms. The maps included the following data overlaid on an ortho-imagery base layer:

- Flood Hazard Layers from the Our Coast Our Future (OCOF) program that depicts the geographical extent of the following sea level rise/storm surge scenarios: 0 cm SLR/No Storm (Baseline), 25 cm SLR/Annual Storm, 25 cm SLR/20 year Storm, 50 cm SLR/20 year Storm, 100 cm SLR/100 year storm, 200 cm SLR/100 year Storm.
- Various GIS layers from the CDA and partner organizations of assets including: beaches, parks, trails, historic sites, wetlands, habitat areas, oyster beds, residential and commercial development, community centers, schools, roads, recreational areas, and more.

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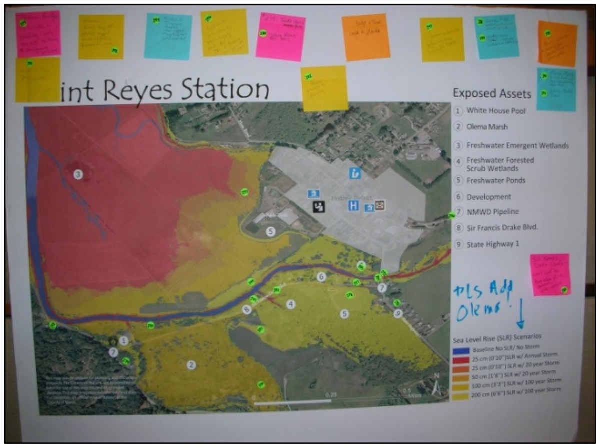

Community maps were created for the following areas: Dillon Beach, Lawson's Landing, Marshall, northern Inverness, southern Inverness, Point Reyes Station, eastern Bolinas, western Bolinas, southern East Shore, Seadrift, Stinson Beach, and Muir Beach. Additionally, two regional maps, Northern Coastal Marin and Southern Coastal Marin, were provided as a means to identify assets which did not fall onto one of the community maps. The exposed assets were listed along the right hand side of the map, with each asset identified by a unique number. The unique number was also placed on the map itself to identify the specific location.

Mapping stations were set up around the room with post-it notes, markers, and pairs of numbered round sticky dots. During the meeting, participants were invited to visit the stations and add additional assets that may be exposed to SLR. This was done by placing the numbered sticker at the asset's location on the map, and then placing the corresponding sticker on a post-it note with their comment and then place is in the white space around the map. On the post-it notes participants identified and described the asset. Participants were also encouraged to make any corrections to the map or add details to existing assets to highlight their importance. Following the meeting, a GIS layer of the assets was created to update the maps.

Vulnerability Discussion

The next workshop activity, Vulnerability Discussion, asked small groups based upon community to discuss the following three questions:

1. What changes are you seeing in your community because of sea level rise or high tides (e.g. January/February king tides)?
2. In what ways do you feel that you, your community, and the coast are at risk to sea level rise and storm surges? How could these risks impact your daily lives/livelihoods, or the lives of future generations?
3. What are some potential solutions? These are ideas which we can further refine in the next set of public workshops when we discuss adaptation strategies.

Participants had ten minutes to write individual responses on the questionnaire provided, followed by thirty minutes of facilitated discussion. After forty minutes, each group shared key points with the larger group.

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Over the course of the workshops, nearly 50 questionnaires were collected offering over 300 concerns, reactions, and ideas for the future. Comments spanned over 25 different topics (see text box to the right).

Road closure, destruction, and relocation were the most frequently noted concerns amongst participants. Participants named particular segments already compromised during high tides and/or storms and others likely to be compromised with increased sea level rise.

Currently compromised road segments during storms and/or high tides include:

- Highway 1 @ Bolinas Lagoon
- Highway 1 @ Pacific Way
- Highway 1 between Tomales and Point Reyes Station at two points frequently
- Highway 1 south of Green Bridges in Point Reyes Station
- Highway 1 @ Tamalpais Junction
- Calle del Arroyo (Tsunami Route)
- Olema-Bolinas Road
- Seadrift Gate
- Private roads

Potentially compromised road segments include:

- Highway 1 by Pelican and Pacific Ways
- Pacific Way South side
- Sir Francis Drake Blvd. @ Bear Valley Road
- Olema Bolinas Rd (only access)
- Ocean Parkway

Major issues from Vulnerability Discussions

- Road functions
- Cliff/hillside erosion
- Beach/dune erosion
- Railroad embankment erosion
- Emergency services
- Property damage/preparation
- Flooding
- Engagement/education
- Habitat destruction and enhancement
- Tidal impacts
- Water supply
- Septic/leech field/sewer
- Financial burden
- Financial assistance
- Nuclear threats
- Food
- Human health/risk
- Utilities/infrastructure
- Communications
- Legal/regulatory
- Retreat/evacuate
- Study/measure
- Mitigation
- Alternative mobility options

Some road adaptations or adjustments described include:

- Raise Seadrift road
- Use local roads
- Raise Calle del Arroyo
- Establish road alternative from Horseshoe Hill Road
- Enhance Frank Valley Road
- Raise Levee Road
- Raise Highway 1 between Pelican Inn and Dairy Farm Road
- Move highways up, in 100 year intervals
- Renovate and raise seawalls on Highway 1
- Community ownership of Star Route Farm for alternative access to Big Mesa and school rebuild

Flooding was the next greatest current and future concern followed by erosion. Other potential impacts or changes frequently cited include property damage, salt water intrusion in areas for septic and water supply, inaccessible emergency services, and the financial barriers and challenges the communities will face.

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Several ideas were offered for altering legal and regulatory structures to allow for the needed changes to septic, road, and development adaptation measures including:

- Relax and streamline Coastal Act standards and County and California Coastal Commission procedures,
- Redo county policies on building at low elevations,
- Allow relocation up to the hillside,
- Rezone to ensure infrastructure rebuilding,
- Incentivize rain water catchment systems,
- Develop new legal theories, plans, and ordinances to permit moving houses and new subdivisions,
- Modify environmental impacts requirement to reduce the elaboration, cost, and time delays to implement remedial measures,
- Modify building codes to permit and support necessary remediation at reduced costs
- Put land back in common ownership,
- Revise local plans/ordinances through the lens of sea level rise,
- Explore environmental design techniques (soft and hard),
- Allow regulations for alternative septic systems,
- Legalize composting toilets, and
- Allow and encourage permaculture and ecological design.

Participants also noted adjustments to utilities and infrastructure, specifically: decentralizing electricity supply and building seawalls, dikes, larger culverts, and retaining walls.

Finally, of note, participants shared several ideas for improvements to natural habitats that could potentially help minimize sea level rise impacts such as restoring and/or enhancing wetlands. The Giacomini and Muir Beach wetland restoration projects were pointed to as examples. In addition, suggestions were made to enhance National Park Service land at Stinson Beach to buffer the downtown community and adjacent natural resources.

Participants greatly valued the opportunity to engage with other local community members about the challenges Sea Level Rise will bring to their communities.

Handbills were distributed to participants with instructions enabling community members who were unable to attend a public workshop to view the draft exposure maps and provide input via the C-SMART website and/or Open Marin online forum (available in English and Spanish). Additional efforts were also made to further engage the Latino community in Sea Level Rise planning and education.

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Agenda
Collaboration: Sea-level Marin Adaptation Response Team
Fall 2014 Public Workshops

TUES. 10/28/14	WED. 10/29/14	THUR. 10/30/14
6:00 pm to 8:00 pm	6:00 pm to 8:00 pm	6:00 pm to 8:00 pm
INVERNESS YACHT CLUB	STINSON BEACH COMMUNITY CENTER	TOMALES TOWN HALL

6:00 **What do you love about Marin's Ocean Coast** *(soft opening)***?**
Participants are invited to tape pictures, drawing, or written comments to boards.

6:10 **Welcome/Introduction**
Introduction to stakeholder and technical committee members and staff. Also view a brief presentation on Sea Level Rise and C-SMART project.

6:30 **Individual Asset Mapping**
At each asset mapping board, participants are invited to add information to community and regional maps using match-numbered dots and post-its.

6:50 **Vulnerability Discussion (Small Group)**
(Handout: C-SMART Workshop #1 Sea Level Rise At Risk Assets Questionnaire)
Participants are invited to small group discussions about the vulnerabilities to Sea Level Rise and brainstorm possible solutions.

7:40 **Report Back**
7:55 **Meeting Evaluations**
8:00 **Q&A**

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Handout Response Compilation

Date	Place of Residence	Q1: What changes are you seeing in your community because of sea level rise or high tides (e.g. January/ February king tides)?	Q2: In what ways do you feel that you, your community, and the coast are at risk to sea level rise and storm surges? How could these risks impact your daily lives/livelihoods, or the lives of future generations?	Q3: What are some potential solutions? These are ideas which we can further refine in the next set of public workshops when we discuss adaptation strategies.
10/30	San Rafael		Sharing the cost of expensive adjustments	Leaving aside the issue of curbing greenhouse gas emission- in the spectrum of measures between defending existing shorelines and abandoning them. I would lean toward the latter when feasible. Providing Room for wetlands to retreat inland is vital. The resulting costs would be shared.
10/30	Tomales		Highway 1 flooding. Concerns over well intrusion, access, higher cost of living.	Move out of town or block Walker Creek by the bridge. Study various tidal rises given the lay of the land. Grade stream beds, for example.
10/30	Muir Beach	Hillside erosion	Highway 1 access (primary), Pelican Inn and Lagoon Way septic, Pacific Way South side, ocean riders stables, Muir Beach Valley firehouse access, green gulch agriculture	-
10/30	Muir Beach	Jan/Feb. King tides + major storms flood Pacific Way and Highway 1 at Pacific Way, causing traffic to move up to Frank Valley Road until water subsides. Erosion of coastal cliffs, destruction of wetlands, silting of Redwood Creek endangers salmon	Potential of Muir Beach becoming isolated if Highway 1 North to Stinson had a slide and highway 1 by Pelican and Pacific Way got flooded. Damage to ecosystem habitats.	Raise Highway 1 level where it tends to flood between Pelican in and dairy.
10/30	Marshall		Access to my house and to the community	Start mapping actual levels

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10/30	Marshall	I haven't seen anything on Tomales Bay in Marshall on our property (at the water) but then I haven't been looking	Highway 1 and access to outside communities or our homes. Septic systems on private properties	Engineer different type of septic. Raise Highway 1, ferries
10/30	Muir Beach	King Tides equivalent to storm surge tides. Road flooding move frequent and persistent	Roads, commuting, travel, Bayside houses at risk of flooding, septic systems	raising roads, redirecting roads, barriers, raising buildings
10/30	Marshall	When it rains in the winter, highway 1 is cut off between Tomales and Point Reyes Sta. at two points more frequently. Railroad roadbed being eroded severely	All the houses on the bay side will have to be raised. Problem remains with septic fields.	Alternate septic systems with changes and flexibility in regulation
10/30	Marshall		Marshall will become a much different place	What is the relationship between MEA/MCE, energy conservations and resilience, carbon emission reductions
10/30	Marshall	Placed our small boat on the railroad embankment (6-8 ft. above the water) and it washed away in a winter storm, and the embankment itself is badly eroded	Storms could flood the road, fall trees, and knock out power and trapping people in their homes. We don't have cell phone reception and phones often go out too (also AT&T threatens to eliminate service to our landlines). Wells and Septic at risk	Use more solar and wind power, develop new alternative sources of energy. When purchased out home in 1990 we added rocks to shore up the sea wall supporting the old railroad embankment.
10/30	Marshall	Flooding of roads, erosion of shoreline, damage to shoreline properties	Most of the Marshall community on Highway 1 will be disastrously affected by sea level rise and storm surge. Many houses cannot survive without serious remediation. Also highway 1	Modify environmental impacts requirement to reduce the elaboration, cost, and times delays to implement remedial measures. Building codes should be modified to permit and support necessary remediation at reduced costs.

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10/30	Stinson Beach	Flooding at Seadrift gate and major flooding at Tam Junction. Bolinas beach very little useable area even with normal high tide	House may be at risk in Stinson to the extent that the habitable area of the community maybe be substantially less by the end of the century	Raising houses on sticks (but that changes the appearance/aesthetics of the community for use and is costly in an earth quake zone. Re-engineering roads in low lying areas for greater height and drainage
10/29	Stinson Beach	Houses on sticks	Our houses at Seadrift could be flooded or washed away	One road to and from Seadrift. It often floods the road should be heightened and a bride on causeway should be added across to Highway 1
10/29	Stinson Beach	Calle del arroyo washes out in King Tides, beach erosion, elimination	Huge risk from inability to get out the single road in emergencies or floods. Calle del Arroyo is a Tsunami evacuation route serving 100s of people at risk, many elderly. Flooding in Calles where there are no revetments. Fire station inaccessible	raise Calle del arroyo, revetment maintenance along public asset beach front
10/29	Stinson Beach	in ability to pass through areas covered by high water	Risk seems to be increasing. If higher water gets worse. Travel on Marin roads will be affected more and more.	Possible seawalls, raising roadway levels, raising house foundations, etc. Reducing greenhouse gases over long term
10/29	Stinson Beach	Flooding in private roads and beach area, limited access including emergency vehicles to beach area and Seadrift	Loss of assets, limited access to assets, isolation due to damage to transportation corridors. Health risks increases by damage to leach lines	Raising structures and roads, developing near emergency shelters. Developing more sophisticated early warning system for more dire threats

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10/29	Other	Ocean flooding of Stinson Beach north parking lot and adjacent homes when combined with Easkoot Creek flooding from precipitation runoff, and higher freshwater table. Dune erosion at Stinson Beach. Highway 1 flooding north end Bolinas Lagoon.	Dunes and less developed NPS Stinson Beach land provide a buffer for the downtown community. Dune erosion could lead to increased community impacts.	How could NPS lands be managed or restored to provide a natural green shoreline to protect the community and natural resources?
10/29	Stinson Beach	Flooding on Calle Arroyo, changes in the channel between Stinson and Bolinas (getting closer together)	Seadrift, downtown Stinson, and portions of Highway 1 could be flooded, or under water permanently, as well as homes in Calles and Patios. May become uninhabitable for people due to homes and business losses, difficulty in getting access.	Move homes and businesses up to GGNRA
10/29	Stinson Beach	Flooding in lower areas	Seadrift flooding	move to higher ground
10/29	Muir Beach/ Stinson Beach		Lack of government foresight-way behind the curve. This initial study should conclude is very solid options to propose to California Coastal Commission	Retreat and adapt to ever increasing coastal flooding and sea-level impacts. Where is Caltrans? What help can the county give to the property owners for permitting, relocating, and ordinance planning?
10/29	Stinson Beach		need to understand dates better	not sure

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10/29	Bolinas		Highway already totally flooded during high tide/ storms/ wind convergence. Bolinas peninsula southern edge is already falling in, Ocean Parkway already way discontinuous. We will become an island with functionally no access in or out since the only access road is Olema Bolinas Rd is already subject to flooding.	Alternate access roads
10/29	Bolinas	Higher tides	Our town floods, will flood worse, where does the town go? Unable to get food or anything downtown.	Rebuild towns somewhere else? Abandon Bolinas, find alternative routes, seawalls and dikes
10/29	Bolinas	Danger to all downtown school, and farming	We will become an island with no infrastructure or businesses	Rezoning to ensure rebuilding infrastructure (schools, non-profits, commercial businesses)
10/29	Bolinas	More threat of flooding downtown, cliff erosion	Access roads and downtown homes and business, schools, farmland, Paradise valley too, infrastructure all at sea level, loss of downtown is essentially loss of town	High seawalls and dikes, individual change, alternative routes
10/29	-	Tides are coming later, April, with high tide and a storm they can flood in the sunny days	Big changes, less beach. Flooding creates safety issues. Getting stuck not able to drive over the mountain. Less fish to eat.	Education, understanding your neighborhood, when the high tides are, respect the streams and creeks and riparian growth, trails to get to higher ground

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10/29	-	Not much in my neighborhood, highway 1 Bolinas lagoon, H2o seemed to be higher and closer to the road	Highway 1 Sir Francis Drake subject to increased inundation, short-term increased storm surges, longer-term projections may be on the low side if perma frost areas melt and methane emission released	Define critical areas to protect against sea level rise areas to allow SLR to occur, Revise local plans/ordinances thru the lens of SLR. For example reconsider current requirements mandating development in sites subject to SLR, explore environmental design techniques (soft & hard) that think like water, consider establishment of a SLR land trust to enable voluntary purchase of properties subject to SLR not located in areas to be protected.
10/29	Bolinas	Olema Bolinas Rd floods during big storms, downtown flooding has happened in past years	All infrastructure at risk (post office, groceries stores, library, business. Access and egress limited, need road alternative from Horseshoe Hill Rd, housing rebuilding, organic farmland flooded, sewer pump station is downtown, cliff erosion	Community ownership of Star Route Farm to allow alternative access to the Big Mesa and for school rebuild. Sea walls and dikes
10/28	Inverness	King tides, murid beach restoration, sand movement on Drake's Beach	The main risk in Inverness is the closure of Sir Francis Drake Blvd. which would affect traffic (in and out access, park, tourism, and agriculture. It could also be a threat to all utilities (water electricity, telephone, internet, etc.)	Use local roads (although I don't personally recommend this)

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10/28	Inverness		Lives of future generations- very high costs to move building and highways over the next 100 years and thorny legal issues regarding properties being flooded. Trade development rights out of higher lands? Redo CWP to add new owns and subdivisions on higher lands? Just let the owners of flooded properties lose their assets	Move highways up, in 100 year steps. Move towns and subdivisions uphill, in 500 year steps. Develop new legal theories and plans and ordinances to permit moving houses and new subdivisions
10/28	-		We own a lodging in Inverness and closing Sir Francis Drake Blvd. would be a big problem. Most of the homes are dependent on the Blvd.	
10/28	Marshall	Increased concern about the need to repair, reinforce and raise foundations for Marshall's over-water homes, especially in light of daunting regulatory challenges	The entire community of Marshall and Highway 1 along the East shore are at risk. This has the potential of ruining the community with collapsed property values.	With a choice between loss of over-water homes or allowing some relaxation in Coastal Act standards and County and CCC procedures, relaxation and some regulatory streamlining should be considered. Protecting the homes also protects the highway

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10/28	Inverness		Everyone is at huge risk and we are not prepared. Roads, pollution the water, radiation from coastal nuclear power plants, septic tanks, emergency services, food access, water supply, PG&E propane service, road access.	Keep the conversation open. Raise Awareness. Educate. Leave the oil and Gas in the ground. Reduce carbon emissions. Stop consuming so much oil dependent crap. Drive less, walk more. Grow food locally. Local power. Legalize composting toilets. Www.transitonsus.org, www. Transitionnetwork.org. Permaculture. Ecological design. Put land back in common ownership. Look to Europe for solutions.
10/28	Inverness	Not much yet, but add 30" to the really high tides and it's obvious that a lot of homes and roads are vulnerable	Inverness, our house, septic system, and access Sir Francis Drake Blvd are vulnerable	Call the Dutch surge control people. building codes, cell tower, Giacomini as story
10/28	Inverness		Inverness park, grocery store on sir Francis Drake	Teach local residents how to measure tidal rise be aware etc. so they can prepare, work together. Reexamining local building regulations through the lens of sea level rise
10/28	Marshall	water is hitting my dock for the first time at king tide	storm surge could flood homes	-

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10/28	Olema	increased rate of coastal erosion in locations with softer rocks, ground	Salt water intrusion of wells and fresh water sources loss/erosion of archeological, historic, residential, and commercial structures, flooding of roads, trails, buildings, impacts on emergency response times, challenges to getting from place to another, increases in insurance premiums	Restore wetlands to absorb storm surge, relocate roads/highways to locations that wouldn't flood, increase mass transit and bicycle lanes, incentivize rain water catchment systems, catch storm water runoff and store in ground, decentralize public utilities, particularly electricity
10/28	-		closure of SFD at high tides	Let nature rule, not big business. Help if one can.
10/28	Point Reyes Station	King tides + rainfall already flood highway 1south of green bridges in Point Reyes Station, cutting off access to town and emergency services, salt water intrusion. Creating the Giacomini wetlands absorbed flood waters, but probably one protect the roads and homes vulnerable now	People in PRS downtown and on the mesa are safe from flooding but people and animals on the low lands surrounding the Giacomini wetlands are vulnerable to floodwaters from Lagunitas creek and high tides from Tomales Bay. Drinking wells are vulnerable too	-
10/28	-		Everyone will sell Property values will plunge. People will move away from the coast	No solution. There will be no help
10/28	Marshall		inundation of houses, septic tanks, and highway 1, inundation by seawater radioactive from Fukushima, Hanford, etc.	House raising in Marshall and septic tanks. Renovate and raise seawalls on highway 1
10/28	Marshall		Fukushima, Diablo, Columbia, Hanford nuclear threats	-

APPENDIX A

Date	Place of Residence	Q1: What changes are you seeing in your community because of sea level rise or high tides (e.g. January/ February king tides)?	Q2: In what ways do you feel that you, your community, and the coast are at risk to sea level rise and storm surges? How could these risks impact your daily lives/livelihoods, or the lives of future generations?	Q3: What are some potential solutions? These are ideas which we can further refine in the next set of public workshops when we discuss adaptation strategies.
10/28	Inverness		Sir Francis Drake will flood more often and more flooding in Inverness business area, buildings on the water side will be affected first, impacts to wetland	Study soft and hard strategies to keep Sir Francis Drake open. Allow undeveloped areas to flood. Elegant retreat through land trusts. Redo county policies on building low allow relocation up to the hillside. Emergency Response Teams. Improved sediment and erosion control
10/28	Inverness		Is the Giacomini wetland helping? Water level seems lower to me.	-
10/28	Point Reyes Station	Giacomini wetlands have improved conditions	The surge of Tomales Bay and Lagunitas Creek, flooding surrounding areas is my biggest concern. This flooding could devastate my property and farm, cut off access to emergency operations via Sir Francis Drake and Bear Valley Rd.	Raise Levee Rd. The Giacomini wetlands are a brilliant solution.
10/28	Inverness	Meetings are starting to happen, flooding during heavy storm and high tides. Property damage along creek	Stress, pollution of bay waters, road destruction and lack of access	Storing/planting wetland areas with mature plants, raising roads, bridges. Larger culverts/pump stations/ retaining wall, septic issues.
10/28	Marshall		homes on water, septic systems, transportation/Highway 1, legal system	Raise homes on water, move homes to higher ground/elevation relocate. Move highway 1 to higher ground
10/28	Point Reyes Station	higher tides	Flooding of Lagunitas Creek/ Sir Francis Drake/ Highway 1. Can't drive from PRS for groceries etc., if Green Bridge is	More wetlands, pay attention to social justice issue-rich people can move, people cannot

Date	Place of Residence	Q1: What changes are you seeing in your community because of sea level rise or high tides (e.g. January/ February king tides)?	Q2: In what ways do you feel that you, your community, and the coast are at risk to sea level rise and storm surges? How could these risks impact your daily lives/livelihoods, or the lives of future generations?	Q3: What are some potential solutions? These are ideas which we can further refine in the next set of public workshops when we discuss adaptation strategies.
			washed out. Saltwater intrusion in NMWS wells	

APPENDIX B

APPENDIX B: All Vulnerable Assets Table & Exposed Asset Tables

Table B-1: Marin Coast Vulnerable Assets Ranked by Onset & Depth

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability
		Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. Groups of buildings list a maximum flooding value. Roads received a high, used for ranking, and low value along the line segment.)					TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Septic Systems west of Shoreline Highway	4.5'	4.5'	6'	7.5'	10.5'	I, WT, WS, TF
		underground resource					
Stinson Beach	Water Distribution Lines	4.5'	4.5'	6'	7.5'	10.5'	E, WS, TF, I, SI, ES
		underground resource					
Inverness	NMWD Pipeline	underground resource (see Shoreline Highway Pt. Reyes Station to Inverness for depths)					WT, SI, E
Pt. Reyes Station	NMWD Pipeline	underground resource (see Shoreline Highway Pt. Reyes Station to Inverness for depths)					I, SI
Stinson Beach	Calle del Arroyo	7" - 6'11"	3" - 6'8"	8" - 9'6"	2'5" - 12'2"	5'11" - 13'9"	I, TF
Stinson Beach	Upton Beach	4’7”	6’2”	7’5”	9’8”	14’9”	I, E
Stinson Beach	Patios and Calles Buildings	10”+1”4”	10”+6”3”	1'6”+ 7’	4'9”+5’10”	6'5”+ 6’8”	I, WT, WS, TF
Inverness	Inverness Yacht Club	3’2”	4’1”	4’11”	6’10”	10’1”	I, WS, HW
Inverness	Brock Schreiber Boathouse	2’7”	3’6”	4’	5’10”	9’2”	I, E
East Shore	Walker Creek Access Point	2’4”	3’3”	4’2”	6’1”	9’3”	I
Bolinas	Tsunami Evacuation Route	2’4”	1’8”	2’5”	4’2"	7’9”	TF, I, WS, E
Bolinas	Brighton Beach	2’2”	3’5”	4’11”	6’	9’11”	E, WS
East Shore	Livermore Marsh Cypress Grove	2’1”	3’1”	3’11”	5’10”	9’2”	I
East Shore	Hog Island Oyster	2'1"	2'1"	2'10"	4'10"	8'1"	I
Inverness	Shoreline Buildings	2’+1’2”	2’+2’	2’10”+2	4’8”+2'	8'+8‘8”	I, WT, WS, TF
East Shore	Shoreline Buildings	1'9”+1’	1'9”+1’11”’	2'6”+2’	4’3”+2’2”	7’8”+2’2”'	I, WT, WS, TF
Bolinas	Downtown	1’8”+1’5”	1’8”+2’2”	2'7”+2’	4’5”+2’1’	7’9”+1’7”	I, WT, WS, TF

APPENDIX B

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. Groups of buildings list a maximum flooding value. Roads received a high, used for ranking, and low value along the line segment.)					
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
	Buildings						
Inverness	Martinelli Park	1’1”	2’	2’2”	4’1”	7’3”	I, E
Bolinas	Wharf Road	6" - 2'1"	3" - 2'4"	2" - 2'9"	1" - 5'4"	10" - 7'4"	I, TF
East Shore	Shoreline Hwy	3" - 1'7"	3" - 2'4"	3" - 3'	2' - 4'6"	6" - 8'1"	I, TF
Bolinas	Agate Beach	2’1”	1’11”	2’8”	4’8”	9’3”	I
Stinson Beach to Bolinas	Shoreline Hwy	0"- 1'8"	0" - 2'3"	0" - 3'1"	0.4" - 4'10"	0.4" - 8'6"	I, TF
East Shore	Marconi Boat Launch	1’1”	2’	2’11”	4’10”	8’2”	I
Inverness	Tomales Bay State Park	10”	1’10”	2’8”	4’7”	7’10”	I, HS
East Shore	Tony's Restaurant	8”	1’8”	2’6”	4’5”	7’9”	I
East Shore	Tomales Bay Oyster Company	8"	1'5"	2'3"	4'1"	7'5"	I, TF
Stinson Beach	Water District Office	7”	3’3”	4’8”	6’6”	8’8”	TF, I
Stinson Beach	Walla Vista Walkway	3”	1’8”	2’	4’4”	10’4”	I, E
Dillon Beach	Lawson’s Landing Facilities	2”	1’1”	2’11”	3’10”	7’3”	I, E, WS, HW, HS
Pt. Reyes Station	Green Bridge	No depth data	No depth data	2”	2’	9’10”	I, TF
Inverness	Chicken Ranch Beach	2’	3’1”	3’9”	5’5”	8’	I, E, HS
Bolinas	Historic District		3’10”	4’8”	6’4”	10’	I, E
Stinson Beach	Seadrift Buildings	2’5”	4’11”	4’10”	3’4”+8’3”	6’1+ 5’9”	I, WT, WS, TF
Stinson Beach	Stinson Fire Department #2		3’6’’	5’3”	6’10”	9’1”	I, TF, WT
Dillon Beach	Bluff-top buildings	X	X	X	X	X	E
Bolinas	Bluff-top buildings	X	X	X	X	X	E
Muir Beach	Bluff-top buildings	X	X	X	X	X	E
East Shore	Inn on Tomales Bay		2”	11”	2’10”	5’5”	I
Inverness	Sir Francis Drake Blvd.			1" - 3'6"	1" - 4'6"	1" - 7'10"	I, TF, WS

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Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. Groups of buildings list a maximum flooding value. Roads received a high, used for ranking, and low value along the line segment.)					
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Bolinas	Sewage Lift Station			3’3”	5’	8’7”	TF, I
Bolinas	Olema-Bolinas Road			2’8”	4” - 4’4”	2” - 7’11”	I, TF
Pt. Reyes Station	White House Pool/Trail			2’5”	2’3”	5’11”	I
Inverness	Inverness Store			2’5	4’4”	7’6”	TF, I, WT
Bolinas	Bolinas Super Market			8”	2’6”	6’1”	I, E, SI
Pt. Reyes Station to Inverness	Shoreline Hwy			6"	3" - 1'5"	1'9" - 9'7"	I, TF
Inverness	Dana Marsh & Beach Access				3’	6’2”	I, E, SI, HS
Inverness	Motel Inverness				2’9”	5’10”	I, WS, HW
East Shore	Nick's Cove				2’6”	5’10”	
East Shore	Millerton Point				2’5”	5’8”	I, E
East Shore	Historic District				2’5”	4’5”	I
Inverness	Historic District				2’1”	5’1”	TF
Bolinas	Bolinas Library				1’8”	5’3”	I, TF
Bolinas	Bo-Gas Station				1’7”	5’3”	I
Bolinas	Gospel Flats				1’7”	5’3”	I, WT, SI, TF
Bolinas	Community Center Emergency Shelter				1’7”	5’2”	I, E
Bolinas	Community Land Trust Housing				1’2”	4’10”	I
Inverness	Shell Beach at Tomales Bay SP				5”	3’4”	TF, I, WT
Bolinas	Church: Calvary Presbyterian					5’10”	I, TF
Bolinas	Bob Stewart Trail					4’8”	I, TF
Inverness	Tomales Bay Resort					4’	TF
Inverness	Inverness Post Office					3’7”	TF, I, WS, E
East Shore	Shoreline Hwy					3’5”	I, E
Bolinas	Bolinas People's					3’	I, TF

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Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability
		Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. Groups of buildings list a maximum flooding value. Roads received a high, used for ranking, and low value along the line segment.)					TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
	Store						
Point Reyes Station	Olema Marsh Trail					2’9”	I
Pt. Reyes Station	Buildings along Lagunitas Creek					1’8”-3’2”	TF, I
Dillon Beach	Dillon Beach Resort Parking Lot					1’6”	I
Bolinas	Bolinas Post Office					2’9	TF, I
Bolinas	Bolinas Stinson School					2’2”	I, TF, E, WS
Stinson Beach	CA Coastal Trail					1’3	TF, E
Muir Beach	Emergency Access (Green Gulch Center)					SLR + Creek Flooding	TF
Muir Beach	Pacific Way	-	-	-	-	22’’	TF
Pt. Reyes Station	Gallagher Well					underground resource	SI
Dillon Beach (north)	Stemple Creek Recreation Area	X	X	X	X	X	HS
Stinson Beach / Bolinas	Bolinas Lagoon	water resource					HS
Inverness / East Shore	Tomales Bay	water resource					HS
North of Dillon Beach	Estero Americano	water resource					HS
Muir Beach	Green Gulch Creek	water resource					HS
Muir Beach	Redwood Creek	Water resource					HS
Stinson Beach	Easkoot Creek	water resource					HS
Bolinas	Pine Gulch Creek	water resource					HS
East Shore	Keys Creek & Fishing Area	water resource					HS
Pt. Reyes Station	Lagunitas Creek	water resource					HS
Dillon Beach	Sewage Pump	bluff top asset					E

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Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability
		Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. Groups of buildings list a maximum flooding value. Roads received a high, used for ranking, and low value along the line segment.)					TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
	Station						

Source: Marin Map, OCOF Exposure and Flood Depth Data, Asset Manager Interviews

Table B-1: Muir Beach Exposed Assets

Asset	Sea Level Rise (SLR) Scenario						Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
	0	1	2	3	4	5		
	0 SLR	10 inches SLR/ Annual Storm	10 inches SLR/ 20-Year Storm	20 inches SLR/ 20-Year Storm	40 inches SLR/ 100-Year Storm	80 inches SLR/ 100-Year Storm	Yes/No	Impact(s)*
California Coastal Trail						X	N	
Coastal Fire Road						X	N	
Green Gulch Agricultural Area						X	N	
Muir Beach and Dunes		X	X	X	X	X	N	
Muir Beach Parking Lot						X	N	
Muir Beach Picnic Area		X	X	X	X	X	N	
Pacific Way		X	X	X	X	X	Y	TF
Redwood Creek		X	X	X	X	X	N	
Tidal Lagoon		X	X	X	X	X	N	

Source: Marin Map, OCOF Exposure, Asset Manager Interviews

Table B-2: Stinson Beach Exposed Assets (west of Shoreline Highway)

Assets	Sea Level Rise (SLR) Scenario						Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
	0	1	2	3	4	5		
	0 SLR	10 inches SLR/ Annual Storm	10 inches SLR/ 20-Year Storm	20 inches SLR/ 20-Year Storm	40 inches SLR/ 100-Year Storm	80 inches SLR/ 100-Year Storm	Yes/No	Impact(s)*

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Beach Access		X	X	X	X	X	N	
Boat Launch		X	X	X	X	X	N	
California Coastal Trail					X	X	Y	E
Emergency Generator			X	X	X	X	N	
Emergency Oil Boom Trailer					X	X	N	
Inlet/Outlet Valves (W)	X	X	X	X	X	X	N	
Inlet/Outlet Valves (E)			X	X	X	X	N	
Seadrift Seawall		X	X	X	X	X	Y	I, WS
Alder Grove Well #3	**	**	**	**	**	**	Y	WT, SI, I, TF
Fire Station #2		X	X	X	X	X	Y	I, TF, WT
Picnic Area /Parking		X	X	X	X	X	Y	I
Septic Systems (bldgs as proxy)		X	X	X	X	X	Y	I, WT, WS, TF, HW, HS
SBWD Water Distribution Lines		X	X	X	X	X	Y	E, WS, TF, I, SI, ES
Tsunami Evacuation Route		X	X	X	X	X	Y	TF, I, WS, E
Upton Beach	X	X	X	X	X	X	Y	I, E
Walla Vista Walkway		X	X	X	X	X	Y	I, E
Water District Office		X	X	X	X	X	Y	I

Source: Marin Map, OCOF Exposure, Asset Manager Interviews

Table B-3: Bolinas Exposed Assets

Asset	**Sea Level Rise (SLR) Scenario**						**Vulnerability** TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
	0	**1**	**2**	**3**	**4**	**5**		
	0 SLR	**10 inches SLR/ Annual Storm**	**10 inches SLR/ 20-Year Storm**	**20 inches SLR/ 20-Year Storm**	**40 inches SLR/ 100-Year Storm**	**80 inches SLR/ 100-Year Storm**		
							Yes/No	**Impact(s)***
Bolinas Community Center Emergency Shelter						X	Y	I, TF
Bolinas Community Land Trust Housing						X	Y	I, TF
Bolinas Library						X	Y	I, TF
Bolinas Stinson School						X	Y	I, TF
Calgary Presbyterian Church	X	X	X	X	X	X	Y	I, TF
The Wye (Shoreline Hwy)	X	X	X	X	X	X	Y	I, TF, E, WS
Lighter Wharf	X	X	X	X	X	X	Y	I, E, WS
Fairfax-Bolinas Road							N	
Olema-Bolinas Road	X	X	X	X	X	X	Y	I, E
Bob Stewart Trail							Y	I, E
Agate Beach	X	X	X	X	X	X	Y	I

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Asset	Sea Level Rise (SLR) Scenario						Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
	0	1	2	3	4	5		
	0 SLR	10 inches SLR/ Annual Storm	10 inches SLR/ 20-Year Storm	20 inches SLR/ 20-Year Storm	40 inches SLR/ 100-Year Storm	80 inches SLR/ 100-Year Storm	Yes/No	Impact(s)*
Sewage Lift Station						X	Y	I
Lagoon Trail							N	
Organic Farming							N	
Paradise Valley							N	
Bo-Gas Station						X	Y	I, TF
Historic District			X	X	X	X	Y	I, E
The Terraces							Y	E, WS
Bolinas People's Store						X	Y	I
Bolinas Super Market						X	Y	I
Gospel Flats	X	X	X	X	X	X	Y	I, WT, SI, TF
Brighton Beach	X	X	X	X	X	X	Y	I
Bolinas Post Office						X	Y	I, WT, TF

Source: Marin Map, OCOF Exposure, Asset Manager Interviews

Table B-5: Pt. Reyes Station Exposed Assets

Asset	Sea Level Rise (SLR) Scenario						Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
	0	1	2	3	4	5		
	0 SLR/ 0 Storm	10 inches SLR/ Annual Storm	10 inches SLR/ 20-Year Storm	20 inches SLR/ 20-Year Storm	40 inches SLR/ 100-Year Storm	80 inches SLR/ 100-Year Storm	Yes/No	Impact(s)*
Golden Gate National Recreation Area						X	N	
Green Bridge		X	X	X	X	X	Y	I
Green Bridge Access Point	X	X	X	X	X	X	Y	I
Love Athletic Field and Venue						X	N	
NMWD Pipeline							Y	I, SI
North Levee Trail						X	N	
Olema Marsh Trail		X	X	X	X	X	Y	I
Gallagher Well						X	Y	SI
White House Pool/Trail		X	X	X	X	X	Y	I

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Asset	Sea Level Rise (SLR) Scenario						Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
	0	1	2	3	4	5		
	0 SLR/ 0 Storm	10 inches SLR/ Annual Storm	10 inches SLR/ 20-Year Storm	20 inches SLR/ 20-Year Storm	40 inches SLR/ 100-Year Storm	80 inches SLR/ 100-Year Storm	Yes/No	Impact(s)*
Trinka Marris Farm					X	X	N	

Source: Marin Map, OCOF Exposure, Asset Manager Interviews

Table B-4: Inverness Exposed Assets

Asset	Sea Level Rise (SLR) Scenario						Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
	0	1	2	3	4	5		
	0 SLR	10 inches SLR/ Annual Storm	10 inches SLR/ 20-Year Storm	20 inches SLR/ 20-Year Storm	40 inches SLR/ 100-Year Storm	80 inches SLR/ 100-Year Storm	Yes/No	Impact(s)*
Brock Schreiber Boathouse & Beach	X	X	X	X	X	X	Y	I, E
Dana Marsh/Beach Access		X	X	X	X	X	Y	I, E, SI, HS
Golden Hinde Inn & Marina						X	Y	WS, HW
Helicopter Pad		X	X	X	X	X	N	
Historic District						X	Y	TF, I, WT
Inverness Post Office						X	Y	TF, I, WT
Inverness Store				X	X	X	Y	TF, I
Inverness Yacht Club	X	X	X	X	X	X	Y	I, WS, HW
Kayak Launch		X	X	X	X	X	N	
Martinelli Park		X	X	X	X	X	Y	I, E
Motel Inverness		X	X	X	X	X	Y	I, WS, HW
Shell Beach (Tomales Bay SP)						X	Y	I, E
Sir Francis Drake Blvd.						X	Y	
Shields Saltmarsh					X	X	N	
Tomales Bay State Park		X	X	X	X	X	Y	I, HS
Tsunami Evacuation Route						X	N	
Water Main				X	X	X	Y	WT, SI, E

Source: Marin Map, OCOF Exposure, Asset Manager Interviews

Table B-5: East Shore Exposed Assets

Asset	Sea Level Rise (SLR) Scenario						Vulnerability TF: Temp. Flooding during
	0	1	2	3	4	5	

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	0 SLR	10 inches SLR/ Annual Storm	10 inches SLR/ 20-Year Storm	20 inches SLR/ 20-Year Storm	40 inches SLR/ 100-Year Storm	80 inches SLR/ 100-Year Storm	extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
							Yes/No	Impacts*
Aquaculture Facilities	X	X	X	X	X	X	Y	SI, E
Estero Road		X	X	X	X	X	Y	I, E
Historic District						X	Y	I
Hog Island Oyster	X	X	X	X	X	X	Y	I
Inn on Tomales Bay				X	X	X	Y	I, E, SI
Livermore Marsh Cypress Grove		X	X	X	X	X	Y	I
Marconi Boat Launch		X	X	X	X	X	Y	I
Marconi Conference Center		X	X	X	X	X	N	
Miller Park Boat Launch		X	X	X	X	X	Y	I
Millerton Point					X	X	Y	I, E
Nick's Cove							Y	I
State Route 1		X	X	X	X	X	Y	I, E
Rock Revetment							N	
Tony's Restaurant		X	X	X	X	X	Y	I
Upper Bluff Wall							Y	E
Walker Creek (Coastal Access)	X	X	X	X	X	X	Y	I

Source: Marin Map, OCOF Exposure, Asset Manager Interviews

Table B-6: Dillon Beach Exposed Assets

Asset	Sea Level Rise (SLR) Scenario						Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift	
	0	1	2	3	4	5		
	0 SLR/ 0 Storm	25 cm SLR/ Annual Storm	25 cm SLR/ 20 Year Storm	50 cm SLR/ 20 Year Storm	100 cm SLR/ 100 Year Storm	200 cm SLR/ 100 Year Storm	Yes/No	Impact(s)*
Cross Country Pipeline	**	**	**	**	**	**	Y	
Dillon Beach	X	X	X	X	X	X	Y	I
Sewer System	**	**	**	**	**	**	Y	E, WS
Lawson’s Landing	X	X	X	X	X	X	Y	I, E, WS, HW, HS
DB Resort Parking Lot					X	X	Y	I
Agricultural Lands	**	**	**	**	**	**	N	
Estero Americano	X	X	X	X	X	X	Y	HS
Stemple Creek Recreation Area		X	X	X	X	X	Y	HS

Source: Marin Map, OCOF Exposure, Asset Manager Interviews

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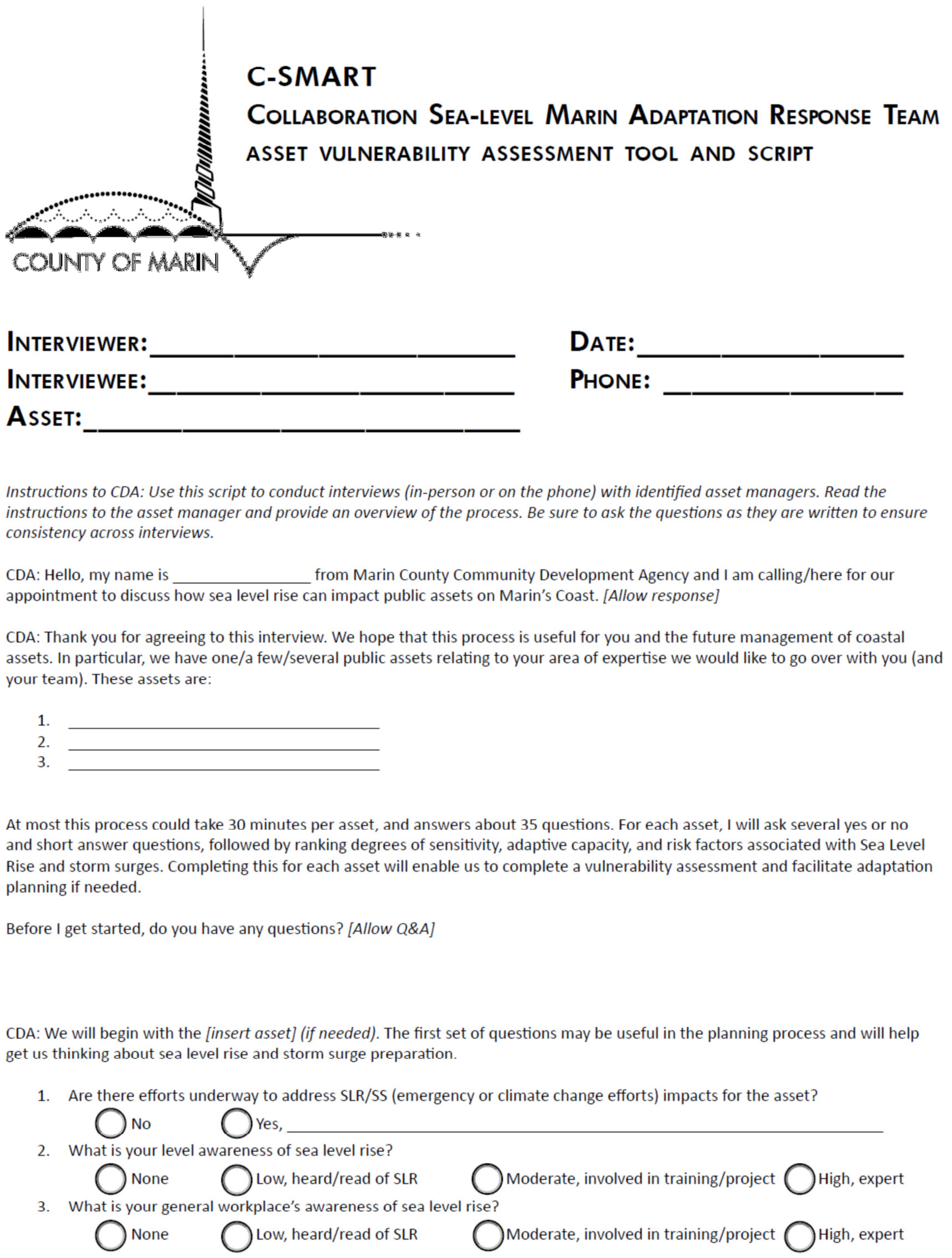
APPENDIX C: Vulnerability Assessment Interview Tool



C-SMART

Collaboration Sea-level Marin Adaptation Response Team

ASSET VULNERABILITY ASSESSMENT TOOL AND SCRIPT

Interviewer:_________________________ **Date:**__________________

Interviewee:_________________________ **Phone:** ________________

Asset:______________________________

Instructions to CDA: Use this script to conduct interviews (in-person or on the phone) with identified asset managers. Read the instructions to the asset manager and provide an overview of the process. Be sure to ask the questions as they are written to ensure consistency across interviews.

CDA: Hello, my name is ________________ from Marin County Community Development Agency and I am calling/here for our appointment to discuss how sea level rise can impact public assets on Marin's Coast. *[Allow response]*

CDA: Thank you for agreeing to this interview. We hope that this process is useful for you and the future management of coastal assets. In particular, we have one/a few/several public assets relating to your area of expertise we would like to go over with you (and your team). These assets are:

1. ____________________________________
2. ____________________________________
3. ____________________________________

At most this process could take 30 minutes per asset, and answers about 35 questions. For each asset, I will ask several yes or no and short answer questions, followed by ranking degrees of sensitivity, adaptive capacity, and risk factors associated with Sea Level Rise and storm surges. Completing this for each asset will enable us to complete a vulnerability assessment and facilitate adaptation planning if needed.

Before I get started, do you have any questions? *[Allow Q&A]*

CDA: We will begin with the *[insert asset] (if needed)*. The first set of questions may be useful in the planning process and will help get us thinking about sea level rise and storm surge preparation.

1. Are there efforts underway to address SLR/SS (emergency or climate change efforts) impacts for the asset?
   ○ No ○ Yes, ____
2. What is your level awareness of sea level rise?
   ○ None ○ Low, heard/read of SLR ○ Moderate, involved in training/project ○ High, expert
3. What is your general workplace's awareness of sea level rise?
   ○ None ○ Low, heard/read of SLR ○ Moderate, involved in training/project ○ High, expert

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4. Please describe the current physical condition of the asset. Are there existing stresses, are they likely to improve/worsen?

5. Has the asset been disrupted in the past due to an unplanned stress e.g., weather-related closure, emergency repair, strike?
   ○ No ○ Yes. How long did disruption last? ___________
   7a. Was the asset able to continue functioning? ○ No ○ Partially ○ Yes

6. When was the last repair or update? ____________
7. Is any major maintenance or repair planned? ○ No ○ Yes, when________

CDA: Thank you. Please consider how the following sea level rise and storm surge exposures could impact *[insert asset]*. The exposures include:

- Rising water table
- Saltwater intrusion
- Permanent flooding
- Temporary flooding
- Wave impacts
- High winds impacts
- Beach/cliff erosion
- Habitat shifts

Do you have any questions about what any of these exposures are? *[Allow response, and clarify if needed]*

First we will address sensitivity, then adaptive capacity, adaptation ideas, and risk for each. For the sensitivity assessment, sensitivity is defined as the degree an asset could be damaged or the service it provides disrupted. Please indicate if ___________________________ will be sensitive for each exposure according to these levels:

No Sensitivity: Not impaired, damaged, or disrupted

Low Sensitivity: Minimally impaired, damaged, or disrupted. The asset may require minor repairs or suffer minimal disruption.

Medium Sensitivity: Somewhat impaired, damaged, or disrupted. The asset may require repairs and able to maintain most functions.

High Sensitivity: Greatly impaired, damaged, or disrupted with complete loss or shut-down. The asset will require significant repairs and disruption could impact public health and safety.

Maximum Sensitivity: Permanent loss or disruption.

Unknown

Do these rankings make sense? Do you have any questions about sensitivity? *[Allow response, and clarify if needed]*

How sensitive is *[insert asset]* to:	No	Low	Med	High	Max
8. Temporary flooding?	○	○	○	○	○
9. Permanent flooding?	○	○	○	○	○
10. Cliff/beach erosion?	○	○	○	○	○
11. Water table rising?	○	○	○	○	○
12. Saltwater intrusion?	○	○	○	○	○
13. Wave surge?	○	○	○	○	○
14. High winds?	○	○	○	○	○
15. Habitat shifts?	○	○	○	○	○

Thank you. To review and confirm, you find that *[insert asset(s)]* is/are moderately, highly, or maximally sensitive to *[name appropriate exposures]*. [If asset is sensitive to any of these exposures, ask the asset manager what the impact of the exposure could be. For example, % reduction in service, hours of system shutdown; what is the NATURE of the sensitivity].

Now we will move onto adaptive capacity. First, we will ask you to rate the adaptive capacity of the asset for each exposure you rated medium, high or maximum. As you may know, adaptive capacity is defined as the ability of an asset to recover from the damage or disruption WITHOUT human intervention. Before we continue, do you have any questions about adaptive capacity? *[Allow for Q & A]*

Please indicate the level of adaptive capacity for the asset according to these categories:

> Maximum Adaptive Capacity: Asset is able to tolerate [impact], no need for intervention.
>
> High Adaptive Capacity: Asset is able to tolerate [impact] and cope with the consequences without the no need for significant intervention or modification (e.g. alternate infrastructure routes, elevated structure). Could be easily replaced, repaired.
>
> Medium Adaptive Capacity: Asset is somewhat able to tolerate [impact], and cope with the consequences with significant intervention or modification (repair, replacement are possible)
>
> Low Adaptive Capacity: Asset has limited ability to tolerate [impact], and cope with the consequences (no alternative routes, no restoration possible. Would require replacement or very costly repairs.
>
> No Adaptive Capacity: Asset is not able to tolerate [impact]. Not reparable or replaceable in current location
>
> Unknown

Please indicate the asset's level of adaptive capacity for each of the moderate, high, and maximum sensitivity exposures. *[insert appropriate exposures into the blanks below]*

	No	Low	Med	High	Max
16.____________________	○	○	○	○	○
17.____________________	○	○	○	○	○
18.____________________	○	○	○	○	○
19.____________________	○	○	○	○	○
20.____________________	○	○	○	○	○
21.____________________	○	○	○	○	○

CDA: Thank you. Now some final questions to get us thinking about adatation planning, the next phase of analysis and exploration.

22. What, if any, existing adaptation or preparation actions have you or your agency incorporated into managing the asset in times of flooding and/or storms?

23. What ideas and next steps do you or your agency have for new adaptation or preparation actions that will ensure the asset/ service the asset provides is maintained in future sea level rise and storm scenarios?

Physical:

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Social:

Financial:

Political:

Now, we will ask about potential consquences for [insert asset]. Responses to these question will help prioritize preparation actions for the most sensitive, least resilient assets. While you may not know the answer, please make your best judgment. If more information is need, please indicate that also [Mark MI next to question #, Skip irrelevant or adjust questions based on asset type].

24. How important is the asset as an economic generator?
    ○ very ○ somewhat ○ not $ ______
25. What is the value to the community?
    ○ high ○ medium ○ low ○ none
26. Does the asset have features that are at-grade or below-grade, e.g., building openings (door, windows, vents) mechanical or electrical equipment, pumps, utilities, building heat, ventilation, power systems or finished basements?
    ○ no ○ yes, ____
27. What would be the cost to repair/ replace the asset?
    ○ high ○ medium ○ low $ ______
28. How many people could be affected?
    ○ region ○ community ○ neighborhood ○ site
    ○ other ○ none
29. Are any underrepresented/vulnerable populations affected?
    ○ no ○ yes, (mark all that apply)
    - ○ People with limited mobility or disability
    - ○ Renters
    - ○ People of color
    - ○ Low income people
    - ○ Seniors over 75
    - ○ Institutionalized populations (hospitals, nursing homes, prisons)
    - ○ Households with limited English proficiency
    - ○ Households lacking vehicle
    - ○ Other ____________________
30. Are there health impacts? ○ no ○ yes, _____________________________________
31. Are there safety impacts? ○ no ○ yes, _____________________________________
32. What is the spacial extent or scale of the impact?
    ○ regional ○ local ○ site ○ less than site

This concludes the questions we have for you for this asset. Is there anything else you would like to share or believe we missed? *[Allow for response, if there are more assets to discuss, restart the interview process for the next asset].* **[When finished all relevant assets]** CDA: Thank you so much for your generous time. We aim to have this information compiled and presentable in the coming months.

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Asset	Asset Manager/ Representative	Interviewer	Date	Method
Buildings	Bill Kelley	A. Westhoff	Jan. 20, 2015	In person
Federal Park lands	Daphne Hatch, Kristen Ward, Brian Aviles	B. Van Belleghem	Feb. 11, 2015	In person
County Parks (Agate Beach, Bob Stewart Trail)	Craig Richardson, Brian Sanford, Dan Sauter, Max Korten, Ari Golan	B. Van Belleghem, A. Westhoff	Feb. 24, 2015	In person
MALT Ag lands	Jeff Stump	B. Van Belleghem	Feb. 25, 2015	Telephone
Lawson's Landing	Mike Lawson, Carl Vogler	B. Van Belleghem	Feb. 26, 2015	Site Visit
Inverness USPS	Lynn Baring, Postmaster	B. Van Belleghem	Feb. 26, 2015	Site Visit
NMWD (Invereness, PRS water)	Chris DeGabriele, Rovert Clark, Drew McIntyre	B. Van Belleghem, A. Westhoff	Feb. 27, 2015	In person
Stinson Beach Fire Stat. no. 2	Kenny Stevens	B. Van Belleghem	March 3, 2015	Telephone
Bolinas-Stinson School Sites	Jennifer Pfeiffer, Martin Honzik	B. Van Belleghem	March 6, 2015	Site Visit
Office of emergency Services (emergency shelters, tsunami routes, CERTs)	Ursula Hanks	A. Westhoff	March 9, 2015	In person
Seadrift Association	Jeff Loomans, Kiren Niederberger	B. Van Belleghem, A. Westhoff	March 13, 2015	Site Visit
Green Gulch Zen Center	Sara Tashker	B. Van Belleghem	March 19, 2015	Site Visit
Bolinas Public Utilities District	Bill Pierce, Director	B. Van Belleghem	March 25, 2015	Site Visit
Archeological Sites	Mike Newland	A. Westhoff	April 1, 2015	Telephone
W. Marin Libraries	Bonnie White	B. Van Belleghem	April 2, 2015	Site Visit
Electrical assets (1 of 2)	Evermary Hickey, Cecile Pinole, PG&E	B. Van Belleghem, A. Westhoff	April 6, 2015	In person
Shoreline Highway	Jeff Peterson, Richard Fahey, Caltrans	B. Van Belleghem	April 30, 2015	In person
communication lines	Mike McAffee, AT&T	B. Van Belleghem	May 1, 2015	In person
Exposed County Roads	Bob Gorlarka, Reuel Brady DPW-Roads Division	B. Van Belleghem	May 5, 2015	In person
OSWT Systems	Armando Alegria, CDA	B. Van Belleghem	May 11, 2015	In person
Taxable Property	Roy Givens, Assessor's Office	B. Van Belleghem	May 30, 2015	In person

APPENDIX D

Appendix D

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

www.esassoc.com

memorandum

date 8/31/2015

to Alex Westhoff, Jack Leibster

from James Jackson PE, Bob Battalio PE, Jeremy Lowe

subject Geomorphic Response of Beaches and Marshes

Purpose

As a part of Task 2: Vulnerability Assessment of the Marin County LCP C-SMART project, ESA developed current and future vulnerability of beaches and marshes for the Bolinas-Stinson area and Marshall by considering the geomorphic response of these assets to sea level rise and potential storm events. An abbreviated analysis was also performed for Dillon Beach, Walker and Keys Creeks, Inverness, Point Reyes Station, and Muir Beach to support the Community Profiles section of the Vulnerability Assessment; these were provided separately in the document "Marsh and Beach Vulnerability." The methods and findings for the geomorphic response of beaches and marshes in the Marshall and Bolinas-Stinson areas are presented below.

Beaches

In coordination with the Vulnerability Assessment report, risk levels were determined for the beaches of concern and classified as high, medium or low risk for each OCOF sea level rise (SLR) and storm scenario considered by the County. Risk levels represent the potential that a particular beach resource could be lost to seasonal changes in beach width and/or a typical coastal storm event (one that could occur every 2-5 years). Bolinas, Stinson, Seadrift and Marshall were assessed as separate geomorphic behavioral units.

Geomorphic Response and Risk Assessment

Because the USGS historic erosion rates for erosion in the Seadrift and Stinson areas are zero (no shoreline erosion data for Bolinas beaches), erosion of the shorelines was modeled using only the Bruun rule (Bruun 1962). As sea level rises, the beach profile (and shoreline) is assumed to move inland based on the shape of the beach profile and the amount of sea level rise:

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$$Sea\ Level\ Rise\ Transgression = \frac{increase\ in\ sea\ level}{shoreface\ slope}$$

In order to develop a scheme that relates beach width to risk of loss, we analyzed various storm erosion distances including input data from a previous study covering the County (PWA 2009) and chose the beach width thresholds presented in Table 1 that are based on a coastal storm erosion event that could occur every two to five years. If a beach width narrows to within these proposed distance levels, the beach is at risk of being significantly eroded or even completely lost during a coastal storm. Because storm erosion informed the risk thresholds, erosion from the storms components of the OCOF scenarios were not considered for this analysis. The beach width thresholds do not consider ecological function requirements because there is little published research on the subject.

Table 1. Risk levels for varying beach width.

Beach Width W (m)	Risk level
W > 15	Low
15 > W > 10	Medium
10 > W	High

To tabulate beach widths for the risk analysis, first the existing beach areas were digitized in ArcGIS from the OCOF 2010 shoreline to the back of beach whether at the toe of a cliff, dune, armor or other structure. These areas were then clipped by the projected shoreline erosion hazard zones for each sea level rise scenario that ESA developed previously for this study. The erosion model does not allow the backshore to retreat with the shoreline; this is consistent with the response of armored back beaches (Seadrift) and cliffs (Bolinas) to coastal storm erosion, and also reflects the County's desire not to consider inland transgression of the beach through dunes and into parking lots and other resources in the southern parts of Stinson Beach (assuming active management of these areas into the future).

Projected beach areas for each sea level rise scenario were tabulated and average beach widths were calculated for each scenario by dividing the area of each geomorphic unit by its length. The resulting beach widths and risk levels for each sea level rise scenario are presented in Table 2.

Table 2. Existing and future average beach width and corresponding risk level for select OCOF scenarios.

	Width (m)						**Risk**					
	Base-line	**Scen 1**	**Scen 2**	**Scen 3**	**Scen 4**	**Scen 5**	**Base-line**	**Scen 1**	**Scen 2**	**Scen 3**	**Scen 4**	**Scen 5**
SLR Amount	**0 cm**	**25 cm**	**25 cm**	**50 cm**	**100 cm**	**200 cm**	**0 cm**	**25 cm**	**25 cm**	**50 cm**	**100 cm**	**200 cm**
Bolinas	22	9	9	3	0	0	Low	High	High	High	High	High
Marshall	There are few beaches in the Marshall area,						High	High	High	High	High	High

	each is currently less than 10 meters wide										
Seadrift	38	29	29	14	0	0	Low	Low	Low	Med	High	High
Stinson	53	48	48	32	9	2	Low	Low	Low	Low	Med	High

Bolinas

Bolinas is characterized by small patches of cliff-backed beaches separated by squeezed stretches of sandy shore backed by armored oceanfront homes. A slightly wider patch of beach exists in front of the cliff adjacent to the mouth of Bolinas Lagoon. The beaches at Bolinas are currently above the low risk threshold mainly due to the existing condition (2010 LiDAR) of the wider east beach around the jetty, however the beach width here fluctuates from year to year and has almost completely disappeared in recent times (see Appendix 1 attached). The west beach area is already narrow and at an increasingly high risk of loss with future sea level rise, as the armored cliff and beachfront homes do not allow for landward transgression of the beach zone.

Marshall

Beaches in the Marshall area are limited to a few small pockets either near creek mouths or tucked behind docks and armoring structures. These beaches are currently less than the 10 meter threshold for high risk. Since most are backed by armor they will remain at high risk of loss with future sea level rise, as they cannot migrate upland.

Seadrift

Seadrift was armored after homes sustained significant damage from wave impact and inundation during the 1983 El Nino event (Griggs et al 2005). This stretch of beach is more susceptible to loss due to the fact that it is narrower than Stinson and is armored, and does not have the ability to transgress inland.

Stinson

Stinson is backed by a mix of armored homes and other beachfront structures and unarmored dunes. It is typically wider than Seadrift, and the lack of armor on dunes means the possibility of the beach profile to transgress inland with sea level rise and storm erosion events. However, the beach areas and associated risk levels for future years in Stinson assume no transgression of the backshore, which effectively treats the back of the beach as armored. Allowing the beach to migrate inland may help to sustain it as an ecological and recreational resource into the future, but only at the expense of parking and other beachfront facilities.

Marshes

ESA worked with Jeremy Lowe to conduct a geomorphic assessment of marsh habitats and develop a metric that links marsh function to risk levels associated with future sea level rise. The geomorphic assessment considers future sea levels along with the best available sedimentation data for marsh habitat in the Marshall area and Bolinas Lagoon. Additional analyses were conducted for Walker and Keys Creeks, Inverness, Point Reyes Station, and Muir Beach to support the Community Profiles section of the Vulnerability Assessment; these are provided in a separate document “Marsh and Beach Vulnerability.”

Future Habitat Evolution

A previous study (PWA 2006) discusses the future evolution of the Bolinas lagoon with sea level rise; however the projected rate of sea level rise used was significantly lower than present estimates. An average rate of 2.4 mm/yr (about 4.6 in by 2050) was assumed in the study which is somewhat less than the present estimates of 6.1 mm/yr (12 in by 2050) from NRC 2012. These more recent estimates are much closer to the observed sedimentation rates in Bolinas lagoon and suggest that in the second half of the century, marsh habitats may be strongly affected by sea level rise. Baye (2014) provides a summary of the implications of higher sea level rise projections in Bolinas lagoon:

- Accelerated sea level rise replaces the risk of excessive lagoon sedimentation and tidal prism loss as an overriding ecosystem concern. Long-term lagoon submergence due to accelerated sea level rise is a major challenge to the lagoon's ecosystem health and resilience.
- Sediment values can be neutral, beneficial, or adverse – depending on location, timing, magnitude, and context. Sedimentation is an asset to evolution of the lagoon, not just an impact.
- Accommodation space (room for the lagoon to migrate into lowlands of stream and fault valleys as sea level rises) is a primary concern for the long-term health and stability of Bolinas Lagoon. There should be a major shift in strategy to re-focus on adjacent lowlands for the lagoon's shallowest margins to occupy and maintain its essential upper intertidal marshes and transition zones with terrestrial and riparian habitats.
- The barrier spit (Stinson Beach and Seadrift) and tidal inlet are essential components of its evolution in response to sea level rise and climate change. Future changes in the lagoon's barrier beach and tidal inlet will occur in response to accelerated sea level rise and coastal storms.

Simultaneous with changes in elevation due to sea level rise, salinity is likely to increase due to changing precipitation, runoff, and sea-level rise and will have variable effects on vegetation. Lower salinities are predicted in the winter and early spring that will affect plant recruitment. Callaway (2007) discusses increases in late spring rainfall led to increased diversity in salt marshes adjacent to Bolinas Lagoon. Larger pulses of winter fresh water could increase recruitment for many species, as most salt and brackish marsh vegetation responds positively to freshwater pulses and reductions in salinity. Increasing salinity, especially during the summer growing season, will affect vegetation, with a likely shift of more salt tolerant vegetation establishing inland. However, migration of vegetation inland may not be so simple, as there are large differences in soil conditions from freshwater tidal marshes to salt marshes, and dispersal and recruitment of vegetation could be limited.

Geomorphic Response and Risk Assessment

Most existing tidal marshes are currently dominated by high marsh vegetation and are found at the upper elevation range for tidal marsh ecosystems. Marsh vegetation is directly affected by elevation. It is one of the most important factors affecting frequency, depth and duration of tidal flooding. Site-specific elevations of tidal marsh plants are also affected by exposure and soil type. In general vegetation occurs from just above mean sea level (MSL) to just above mean higher high water (MHHW). Cordgrass is found at lower elevations, while elevations close to MHHW are dominated by pickleweed, along with a number of other species depending on local elevation, drainage, soils, site history and other factors. Similarly, frequently flooded brackish marsh sites have characteristic species (e.g., alkali bulrush) with more salt tolerant vegetation on the marsh plain. The fact that most tidal marshes are relatively high elevation implies that they will remain vegetated even with some loss of elevation.

Because marshes exist at relatively high elevation, they possess substantial "elevation capital" (Cahoon and Guntenspergen 2010). In other words, they have a large amount of elevation to lose before they are converted to unvegetated mudflats. If tidal marshes cannot keep pace with sea level rise and begin to lose elevation, tidal marsh habitat will be lost and converted to unvegetated mudflats when elevations within the marsh drop below the threshold for survival of marsh vegetation. In places where adjacent areas are relatively flat and at slightly higher elevations, marshes could migrate inland. However, if there are areas around the lagoon bordered by road berms or other areas with abrupt elevation changes, migration will be constrained. In areas where migration is physically possible, there also are potential limitations depending on land ownership and future land management decisions.

Elevation Capital

In order to determine the sustainability of marsh habitat, rates of sedimentation, biomass production and changing sea levels must be considered along with the topographic constraints that exist or are imposed upon the marsh. As sea levels rise and marshes are flooded more often, there will likely be some positive feedback to maintain elevation, as lower elevations will lead to greater rates of mineral sediment inputs. However, this feedback depends a lot on the concentration of available suspended sediment. Similarly there is a strong feedback between the inundation regime (frequency, depth and duration of flooding) and organic matter accumulation rates within the marsh. At very low elevations within the marsh, primary biomass production is inhibited by increased stress from anaerobic conditions associated with high rates of inundation. At the upper end of the marsh, salt stress (and potentially competition with non-wetland species) leads to a reduction in wetland primary productivity. Together, these two factors typically result in a peak of biomass productivity somewhere close to or just below marsh plain elevations (Morris et al. 2002).

If a marsh does begin to lose elevation, it may take substantial time for a marsh that is at a high starting elevation (i.e., has substantial elevation capital (Cahoon and Guntenspergen 2010) to lose enough elevation to get to the critical point at which marsh production begins to be reduced. However, if this point is reached, the marsh is likely to lose elevation even more quickly as organic matter productivity is reduced. Eventually the marsh will reach elevations that are so low that no tidal marsh vegetation can continue to grow.

Elevation capital is determined in large part by comparing the absolute elevation of a marsh with the local water levels and tide range (Cahoon and Guntenspergen 2010). Swanson et al (2013) presents a dimensionless indicator (z*) of elevation capital based on mean sea level and tide range:

$$z^* = \frac{z - MSL}{MHHW - MSL}$$

This non dimensional parameter is simple to calculate using existing data (marsh elevation, e.g., from LiDAR and a nearby tidal datum) and makes it possible to compare marshes with different elevations and tide regimes. Figure 1 and 2 show z* for the present day marshes in Bolinas Lagoon and Marshall, respectively. Tidal marshes and flats in west Bolinas Lagoon have a high elevation capital (z*>1). Organic productivity peaks at approximately z* = ~0.3. Below this elevation (at higher levels/frequency of inundation) the system becomes unstable and plants begin to drown. Risk levels were thus correlated to elevation capital as shown in Table 3.

Table 3. Risk levels for ranges of elevation capital (z*, dimensionless).

Elevation Capital	Risk level
2.5 > z* > 1	Low
1 > z* > 0.3	Medium
0.3 > z*	High

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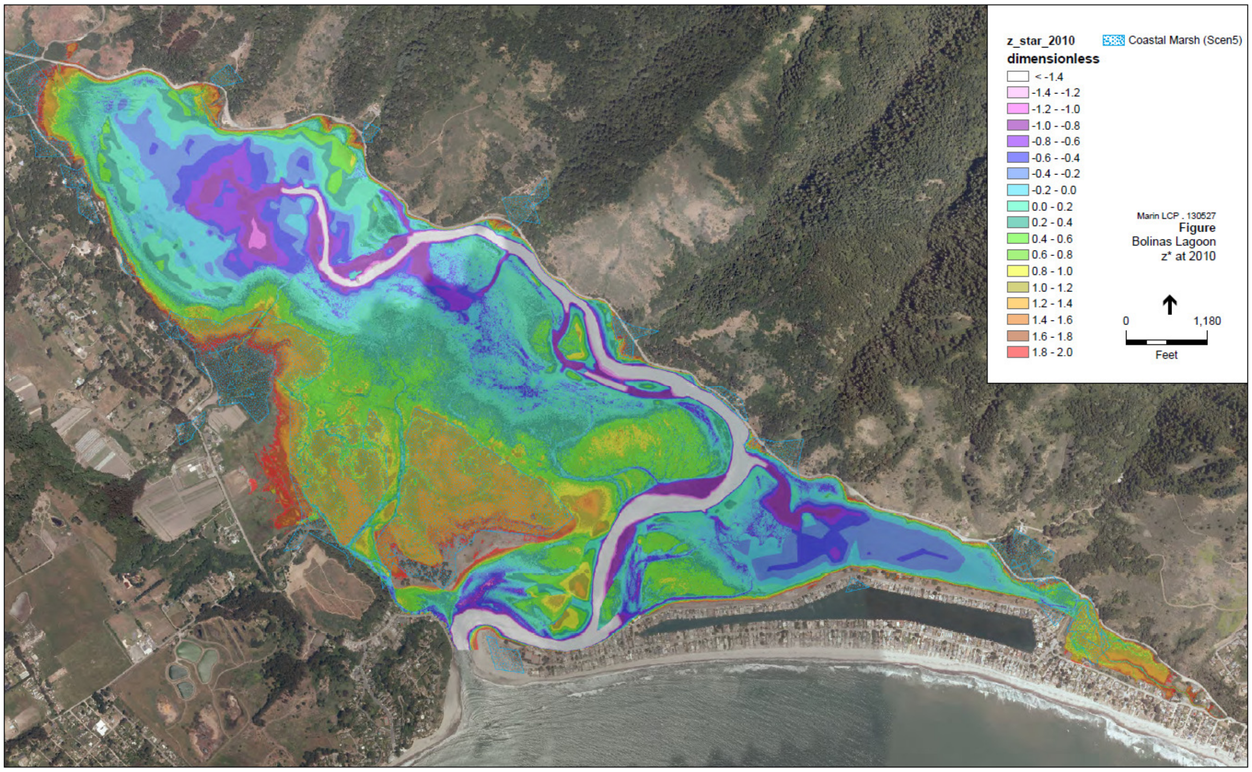

Figure 1. Existing elevation capital (z*) at Bolinas Lagoon.

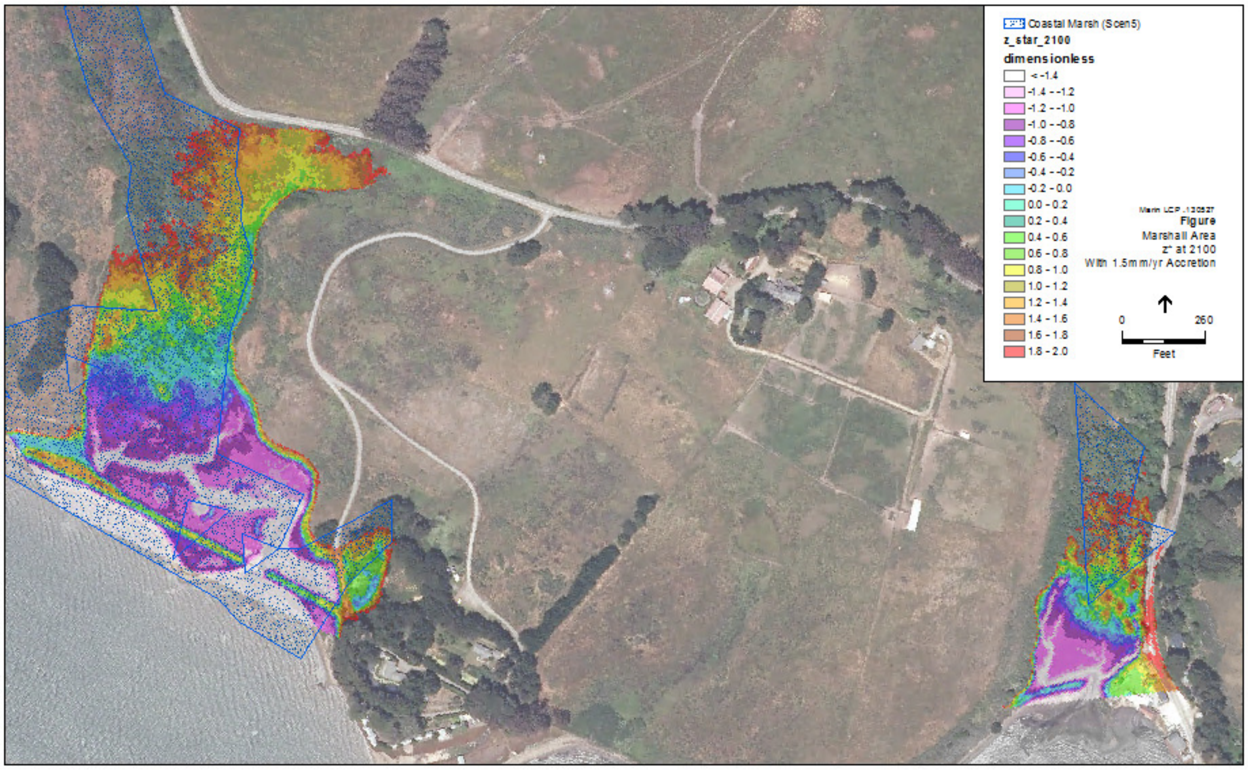

Figure 2. Existing elevation capital (z*) at lagoons near Marshall.

Bolinas Lagoon

Bolinas Lagoon is a tidal embayment sheltered by Stinson Beach Spit (Figure 3). It consists of approximately 1,000 acres of open shallow water, extensive mud and sand tidal flats (approximately 600 acres), flood and ebb tide shoals and deltas, small alluvial fans and deltas, and fringing tidal salt marsh. Kent Island within the Lagoon is an emergent flood tidal delta island with a thin cap of beach and dune sands (PWA 2006).

Figure 3. Bolinas Lagoon (PWA 2006)

The lagoons waters are primarily marine, connected by a tidal inlet which rarely closes - the absence of freshwater pollen from cores is suggests that there has not been closure during the last 1,600 years (Byrne et al 2005). The ability of the tidal inlet to remain open largely depends upon the relative balance between tidal currents and wave-driven sand transport. The equilibrium form of Bolinas Lagoon has historically maintained sufficient tidal prism to keep the inlet open, partially due to the fact that Duxbury Reef shelters the inlet from the prevailing northwesterly swells (PWA 2006).

About 75% of the sediment deposited in the lagoon is derived from beach sands and bluff eroded silts (Byrne et al 2005, PWA 2006). The rate of littoral sediment delivery is largely determined by the competency of flood tide currents to sweep beach sands through the tidal inlet and disperse it inside the lagoon which is in turn controlled by the tidal prism. Finer silt eroded from bluffs is more efficiently transported and less dependent on tidal current velocity.

Ten small seasonal drainages and the perennial Pine Gulch Creek empty into the lagoon and establish local topographic and salinity gradients. The creeks deliver coarser alluvial sediment which accounts for 25% of the sediment budget of the lagoon. Deltas form at the mouth of these creeks, growing in response to increasing sediment load due to channelization in the watershed. The largest delta is associated with Pine Gulch Creek on the west side of the lagoon with the steep creeks that drain Bolinas Ridge being smaller and storing less sediment.

The growth of the Pine Gulch Creek delta has altered the equilibrium form and habitat distribution of Bolinas Lagoon by converting intertidal estuarine habitats to upland riparian woodland. The Pine Gulch Creek delta and Kent Island act to shelter much of the western shoreline of the lagoon from wind waves, allowing mudflats to convert to salt marsh. Therefore most of the fringing tidal marsh is on the west side of the lagoon.

The long term evolution of the lagoon and its overall sedimentation regime is set by its recovery from rapid and repeated subsidence during tectonic events:

> *At any given time, the lagoon morphology is evolving towards a dynamic equilibrium in response to both slowly varying and sudden episodic changes in sedimentation processes. Large earthquakes along the San Andreas Fault punctuate the evolutionary trajectory of Bolinas Lagoon. These events occur on the order of once every several hundred years, and when they occur, seismically-induced compaction results in a nearly instantaneous increase in tidal prism as tectonic subsidence and compaction drops the elevation of intertidal marsh and mudflat*s.
>
> PWA (2006)

The combination of littoral and fluvial sediment sources together with the episodic increase of accommodation space has led to relatively high sedimentation rates in the lagoon. Byrne *et al* (2005) estimate average rates of about 6.8 mm/yr from cores in the North Basin since 1906 compared with an average rate of sea level rise at the Presidio tide gauge of 2.13 mm/yr in the same period. Pollen dating from a core in the South Basin indicated sedimentation rates of 6 mm/yr (Byrne *et al* 2006). PWA (2008) extrapolated the 6.8 mm/yr sedimentation rate to the whole of the lagoon to get an average sediment delivery rate of about 43,000 CY/yr. These estimates come with the caveats that the cores reported in Byrne *et al* (2006) were limited to unvegetated mudflats and subtidal shallows due to permit restrictions. Based on the geometry of the Pine Gulch Creek delta and the known rate of growth of the delta footprint, PWA (2006) estimated the vertical accretion rate of the delta to be about 15 mm/yr in 2050 and about 8 mm/yr by 2150; the rate decrease as the footprint of the delta expands but the sediment supply was held constant.

Tidal flats dominate the intertidal zone. Tidal marshes are associated with deltas and alluvial fans of local drainages, flood tidal delta shoals, and barrier beaches. Brackish marshes of alkali bulrush are associated with freshwater seeps and creeks. The tidal flats, channels, and marsh fringe of the back barrier shoreline were dredged and filled in the 1960s as part of the Stinson Beach development.

A description of the habitats is given in the Northern California Tidal Marsh Recovery Plan (USFWS 2013). Bolinas tidal marshes consist of broad plains dominated by short turf-like vegetation in upper zones, grading to broad pickelweed zones, pickleweed-cordgrass zones, and pure cordgrass stands. Bolinas marshes contain populations of rare annual plants, and once was the type locality for the rare coastal marsh milkvetch, a species now extirpated there. The tidal flats and channels are important habitat for seals, shorebirds, and wading birds. It formerly supported vagrant California clapper rails

Figure 4 shows elevation capital in Bolinas Lagoon for 2010, 2030, 2050, 2100 low and 2100 high SLR for the best case of 6.8 mm/yr sedimentation. As sea level rises the marshes will be restricted more to the

Pine Gulch Creek delta, Kent Island, Easkoot Creek and the Lewis and Wilkins Gulches at the head of the lagoon. These are all areas with gently sloping migrating transition zones, although some of which may only be realized following the realignment of infrastructure such as roads and culverts. Marshes close to the Pine Gulch Creek are also likely to survive longer due to the higher rate of vertical accretion associated with deltaic processes. The acreages of each habitat band in Bolinas Lagoon, defined by z*, are presented in Table 4 for years that correspond to the selected SLR scenarios.

Table 4. Spatial distribution of marsh habitat and risk at Bolinas Lagoon (acres)

Bolinas Lagoon	**area in acres**					
	Base-line	**Scen 1 & 2**	**Scen 3**	**Scen 4**	**Scen 5**	
Habitat type (6.8 mm/yr sedimentation)	**0 cm SLR (2010)**	**25 cm SLR (2030)**	**50 cm SLR (2050)**	**100 cm SLR (2100 low)**	**200 cm SLR (2100 high)**	***z* range***
Transition zone	128.8	122.6	117.8	107.3	65.8	*1.5 - 3*
High salt marsh (salt grass)	164.2	95.3	47.7	42.4	27.3	*1 - 1.5*
Mid salt marsh (pickleweed)	34.7	75.8	42.4	14.3	9.4	*0.84 - 1*
Low salt marsh (cordgrass)	429.6	327.7	305.3	235.6	67.4	*0 - 0.84*
Intertidal Mudflats	386.6	497.4	580.7	600.1	126.1	*-1.04 - 0*
Subtidal Channels and Shallows	67.8	105.5	142.0	253.2	1025.8	*below -1.04*
Risk Level	**area in acres**					***z* range***
Low	254.6	183.7	134.9	115.2	48.7	*1 - 2.5*
Medium	256.7	234.1	221.1	77.8	77.1	*0.3 - 1*
High	662	772.3	849.4	1048.1	1180.1	*below 0.3*

Areas at highest risk are those without gradually sloping transitional uplands or are located away from the creek deltas. Table 4 shows the increasing risk of loss of marsh functions as sea level rises and marshes are squeezed against steeper upland slopes. Approximately 50% of the high marsh (low risk, z* > ~0.3) is expected to be lost by 2050; converting to low marsh, mud and sand flats; this will increase to 80% loss by 2100. This is a conservative estimate as there may be increases in accretion rates and changes in form of sand bodies in the lagoon such as Kent Island which increase protection from wave action and enhance sedimentation rates.

Tomales Bay – Marshall Area

Tomales Bay is formed by the San Andreas Fault, like Bolinas Lagoon, although its size and wide mouth relative to its sediment supply means that it has an incomplete sand barrier at Dillon Beach. Fluvial inputs associated with two watersheds, Walker Creek and Lagunitas Creek, are sufficiently large to create local estuarine gradients within the Bay. Similar to Bolinas Lagoon, the largest tidal marshes are associated with the alluvial deltas of these creeks.

The bay margins are indented with coves and numerous gulches (intermittent and perennial stream valleys) associated with small deltas, beaches, and discrete pocket tidal marshes, riparian vegetation, and lagoons. Fine sediments are prevalent at the head of the bay. Local headlands are sources of coarse sediments; these are eroded and re-deposited in high marshes, beaches and deltas.

The Lagunitas Creek delta expanded in the 19th century due to sediment deposition from watershed erosion, and most of it was diked for agriculture and railroad alignments. Similarly, the Walker Creek delta has expanded rapidly in recent decades due to watershed erosion. At the south end of Tomales Bay are diked baylands, tidal flats and tidal marsh including the Lagunitas Creek delta and Olema marshes.

The vegetation of Tomales marsh plains is similar to that of Bolinas Lagoon, Drake's Estero and Limantour Estero (USFWS 2013). Cordgrass occurs primarily at the head of the estuary in the Lagunitas Creek delta marshes, but also occurs at some smaller deltas. The tidal marshes also support some of the largest populations of rare tidal marsh plants, such as cordylanthus and owl's-clover.

Figure 5 shows elevation capital in Marshall lagoons for 2010, 2030, 2050, 2100 low and 2100 high SLR for the Tomales Bay average historic sedimentation rate of 1.6mm/yr (Smith and Hollibaugh 1998). As sea level rises the high marshes are able to transgress inland along the valley profile. While these are areas with gently sloping migrating transition zones, some realignment of infrastructure such as roads and culverts may have to occur if they are to be realized. The acreages of each habitat band in Marshall area lagoons, defined by z*, are presented in Table 5 for years that correspond to the selected SLR scenarios.

Table 5. Spatial distribution of marsh habitat and risk in the Marshall area of Tomales Bay (acres)

Marshall Area	**area in acres**					
	Base-line	**Scen 1 & 2**	**Scen 3**	**Scen 4**	**Scen 5**	
Habitat type (1.5 mm/yr sedimentation)	**0 cm SLR (2010)**	**25 cm SLR (2030)**	**50 cm SLR (2050)**	**100 cm SLR (2100 low)**	**200 cm SLR (2100 high)**	***z* range***
Transition zone	6.8	7.3	8.2	9.2	8.3	*1.5 - 3*
High salt marsh (salt grass)	4.8	3.5	2.1	2.1	3.5	*1 - 1.5*
Mid salt marsh (pickleweed)	0.8	2.5	2.3	1.0	1.6	*0.75 - 1*
Low salt marsh (cordgrass)	1.4	1.9	4.1	5.9	3.6	*0 - 0.75*
Intertidal Mudflats	1.2	1.6	2.1	2.8	7.5	*-1.17 - 0*
Subtidal Channels and Shallows	na	na	0.0	1.0	4.4	*below -1.17*
Risk Level	**area in acres**					***z* range***
Low	9.2	7.8	6.8	8.5	9.2	*1 - 2.5*
Medium	1.8	3.8	5.6	3.3	4	*0.3 - 1*
High	1.6	2.2	3	7.7	13.1	*below 0.3*

Areas at highest risk are those lowest in elevation. Unlike Bolinas Lagoon there are relatively large areas of transition zone and the acreage of high and mid marsh stays about the same over time. Table 5 shows the increasing risk of loss of marsh functions as sea level rises and marshes are squeezed against steeper upland slopes. The high marsh (low-medium risk, z* > ~0.3) in 2100 is about the same acreage as in 2010. The acreage of mudflat does increase as the former low lying marsh areas are drowned.

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APPENDIX D

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