Union of Concerned Scientists

FACT SHEET

The US Military on the Front Lines of Rising Seas

Exposure to Coastal Flooding at Marine Corps Recruit Depot Parris Island and Marine Corps Air Station Beaufort, South Carolina

HIGHLIGHTS

With seas rising at an accelerating rate, coastal military installations are increasingly exposed to storm surge and tidal flooding. The Union of Concerned Scientists (UCS) conducted analyses of this changing exposure for 18 military installations along the East and Gulf coasts. Analysis for Marine Corps Recruit Depot (MCRD) Parris Island and Marine Corps Air Station (MCAS) Beaufort, both in South Carolina, found that in the second half of this century, in the absence of preventive measures, Parris Island in particular can expect more frequent and extensive tidal flooding, loss of currently utilized land, and substantial increases in the extent and severity of storm-driven flooding to which it is exposed.

The US Armed Forces depend on safe and functional bases, such as MCRD Parris Island and MCAS Beaufort in South Carolina, to carry out their stated mission: to provide the military forces needed to deter war and to protect the security of the country. A roughly three-foot increase in sea level would threaten 128 coastal Department of Defense (DOD) installations in the United States and the livelihoods of the people—both military personnel and civilians—who depend on them (NAS 2011). In the area around Beaufort, seas are projected to rise between 4.0 and 6.4 feet by the end of this century.

To enable decision makers to better understand the sea level rise threat, and where and when it could become acute, UCS has performed a new analysis of 18 East and Gulf Coast military installations, including MCRD Parris Island and MCAS Beaufort. These sites were selected for their strategic importance to the armed forces, for their potential exposure to the effects of sea level rise, and because they represent coastal installations nationwide in terms of size, geographic distribution, and service branch.

UCS projected exposure to coastal flooding in the years 2050, 2070, and 2100 using the National Climate Assessment's midrange or "intermediate-high" scenario (referred to here as "intermediate") and, in light of the low tolerance for risk in some of the military's decisions, a "highest" scenario based on a more rapid rate of increase (Parris et al. 2012).[1] We modeled tidal flooding, permanent inundation, and storm surge from hurricanes.[2] The results below outline potential future flooding to which MCRD Parris Island and MCAS Beaufort could be exposed, assuming no new measures are taken to prevent or reduce flooding.[3] This analysis finds the following key results:

US Marine Corps

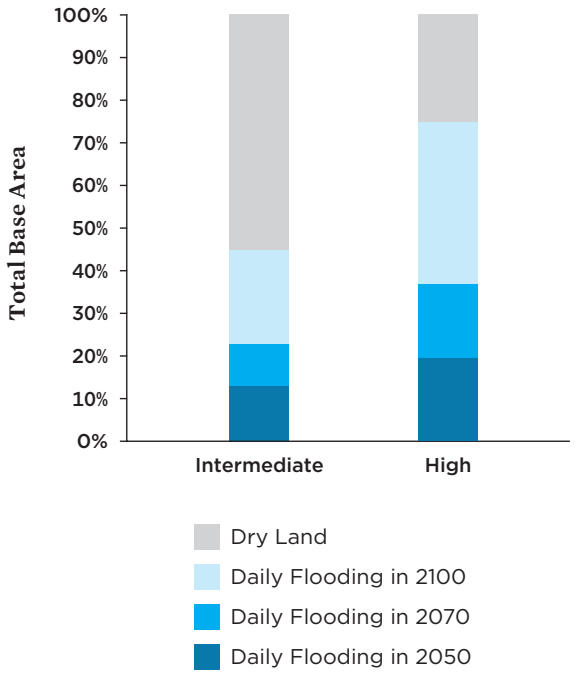
THE INLAND MARCH OF HIGH TIDE

MCRD Parris Island is one of only two installations in the nation where marine recruits are trained. Much of the land consists of marshes and the majority of the base lies less than 10 feet above sea level. With between 4.0 and 6.5 feet of sea level rise expected later this century, major land losses are foreseeable.

TIDAL FLOODING, PERMANENT INUNDATION, AND LAND LOSS

- **Certain areas face daily high tide flooding**. Today, tidal flooding affects low-lying locations around MCAS Beaufort and MCRD Parris Island, including extensive wetland areas, 10 times per year on average. By 2050, the currently flood-prone areas within both bases could experience tidal flooding more than 300 times annually and be underwater nearly 30 percent of the year given the highest scenario.
- **Flooding during extreme high tides will become more extensive**. Later this century, the higher water levels caused by extreme tides could inundate 85 percent of MCRD Parris Island's land, both wetlands and developed areas, roughly 10 times per year given the highest scenario.
- **Extensive land loss at MCRD Parris Island is possible**. Parris Island is already highly prone to flooding. A projected 6.4 feet of sea level rise (the highest scenario) by 2100 would inundate three-quarters of MCRD Parris Island's land, including developed areas, with the daily high tides.

FIGURE 1. Land Loss at MCRD Parris Island



As high tide reaches farther inland, extensive land loss is possible at MCRD Parris Island. Affected land may include developed and undeveloped areas and even wetlands that reside above the current high tide mark. Substantial loss of currently utilized areas is projected.

STORM SURGE

- **Sea level rise exposes previously unaffected areas of MCRD Parris Island and MCAS Beaufort to storm surge flooding**. In this relatively low-lying area, sea level rise will have a substantial effect on the extent of inundation. In 2100 in the intermediate scenario, sea level rise increases the area of MCAS Beaufort exposed to flooding during all categories of storms by about 10 percent compared to today; exposure to flooding increases nearly 15 percent in the highest scenario.
- **Sea level rise exposes MCRD Parris Island and MCAS Beaufort to deeper, more severe flooding**. As sea level rises, the depth of inundation related to storm surge increases. In general, over time, the area inundated by five feet or more of seawater during storm surges increases. In an end-of-century worst-case scenario involving a Category 4 storm, a predicted six feet of sea level rise could double the area exposed to flood depths of 20 feet or more at MCAS Beaufort—from 17 to 34 percent of the installation.

Base Information

MCAS Beaufort and MCRD Parris Island are located in Beaufort County, just south of the city of Beaufort in South Carolina Lowcountry. The region is relatively low lying, particularly MCRD Parris Island, where much of the land consists of marshes and the majority of the installation lies less than 10 feet above sea level. The region is also home to US Naval Hospital Beaufort and a Marine Corps housing complex.

MCAS Beaufort

Branch:	Marine
Established:	1943
Size (Acres):	7,808
MC Squadrons:	7
Navy Squadrons:	2
Marines and Sailors:	700
Civilian Personnel:	600

MCRD Parris Island

Branch:	Marine
Size (Acres):	5,615
Annual Recruits:	19,000

SOURCE: BEAUFORT ONLINE 2016; GLOBAL SECURITY.ORG 2011.

MCAS Beaufort is home to one of the largest military airstrips in the world as well as fighter and attack squadrons belonging to both the Marine Corps and the Navy (Beaufort Online 2016). MCRD Parris Island lies to the south of MCAS Beaufort and is one of only two installations in the nation where marine recruits are trained (Global Security.org 2011).

Historic Exposure to Storm Surge and Flood Hazards

From 1900 to 2009, eight hurricanes struck Beaufort County, including four Category 1, two Category 2, and two Category 3 hurricanes (NHC 2010). The surrounding area has seen a greater amount of hurricane activity: since 1851, 58 hurricanes have tracked within 150 nautical miles of MCRD Parris Island (NOAA n.d.), 37 of them within 75 miles. Current estimation of the annual chance of a hurricane affecting Beaufort County is 13 percent (LCGPD 2009).

Future (Projected) Exposure to Storm Surge and Flood Hazards

SEA LEVEL RISE

The intermediate scenario projects that both installations will experience 4.0 feet of sea level rise and the highest scenario projects 6.4 feet of rise by 2100. This rise will lead to increased exposure to different types of coastal flooding.

TIDAL FLOODING AND LAND LOSS

As sea level rises, extreme tide flooding—flooding that reaches beyond the daily high tide mark—is expected to become more extensive and frequent. Low-lying areas, including large portions of MCRD Parris Island, mainly wetlands, are already exposed to flooding during extra-high tides 10 times per year on average. The frequency of tidal flooding in these areas increases steeply over this century in both scenarios until flood-prone areas flood with each high tide, as outlined in Table 2 (p. 4). Areas currently affected by occasional tidal flooding could flood daily. Depending on the scenario, flood-prone areas in this region experience between 150 and 325 floods, approximately, per year by 2050—compared to less than a dozen today. In the highest scenario, flood-prone areas throughout the region experience flooding with each of the two daily high tides and are underwater roughly 30 percent of the time by 2070. And by late century, 85 percent of the installation's land area would be inundated during extreme tides, approximately 10 times per year (see Figure 3, p. 5).

MCAS Beaufort, with less low-lying land than MCRD Parris Island, will be less directly affected by tidal flooding. Shown here are flood events in low-lying areas projected by the intermediate and highest scenarios. As flood conditions begin to span multiple tide cycles, the rate of increase in distinct flood events slows, but the duration of flooding increases. Events per year are reported as the average over a five-year period with one standard deviation. Percent of year is reported simply as the average over a five-year period.

TABLE 1. Beaufort Area Bases: Projected Sea Level Rise (Feet) in Two Scenarios

Year	Intermediate	Highest
2050	1.2	1.8
2070	2.1	3.3
2100	4.0	6.4

In the intermediate scenario, ice sheet loss increases gradually in the coming decades; in the highest scenario, more rapid loss of ice sheets occurs. The latter scenario is included in this analysis to help inform decisions involving an especially low tolerance for risk. Moreover, recent studies suggest that ice sheet loss is accelerating and that future dynamics and instability could contribute significantly to sea level rise this century (Rignot et al. 2011; Chen et al. 2013; Trusel et al. 2015; DeConto and Pollard 2016). Values shown are local projections that include unique regional dynamics such as land subsidence (see www.ucsusa.org/MilitarySeasRising).

With about three feet of sea level rise, nearly 40 percent of MCRD Parris Island's land area—including roadways and facilities—would be exposed to flood with each high tide; if sea level rises more than six feet, as projected for the end of the century in the highest scenario, three-quarters of the installation's land area would become part of the tidal zone (see Figure 1). Sitting at a higher elevation, MCAS Beaufort is expected to experience far less of this flooding.

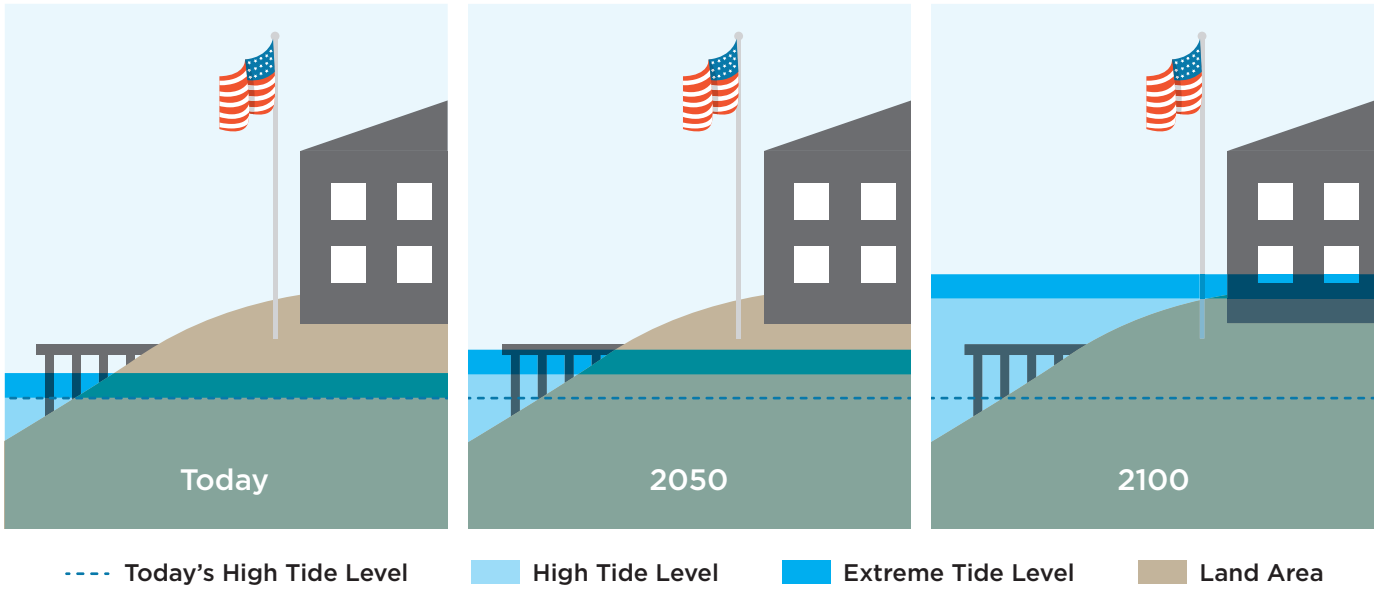
THE CHANGING THREAT OF HURRICANES

MCRD PARRIS ISLAND

Category 1 hurricanes are the most likely type to affect this area. Ninety percent of MCRD Parris Island is exposed to storm surge flooding from a Category 1 storm today. Most of that flooding would be five to 10 feet deep. In the intermediate scenario, over 95 percent of the installation is exposed to storm surge flooding from a Category 1 storm by 2100, the equivalent to the area exposed to flooding during a Category 2 storm today. Flood depth also increases as sea level rises: by 2100, nearly 70 percent of the installation is exposed to flooding 10 to 15 feet deep.

A Category 4 storm hitting in 2100 in the highest scenario is the worst-case scenario for the area in this analysis. All of MCRD Parris Island would be exposed to storm surge. Nearly 90 percent of the flooding would be more than 20 feet deep.

FIGURE 2. How Sea Level Rise Causes Tidal Flooding and Land Loss



As sea level rises, local flood conditions can happen more often, to a greater extent, and for longer time periods when extreme tides occur. And the daily high tide line can eventually begin to encompass new areas, shifting presently utilized land to the tidal zone. In this analysis, land inundated by at least one high tide each day is considered a loss. This is a conservative metric: in reality, far less frequent flooding would likely lead to land being considered unusable.

MCAS BEAUFORT

Sea level rise will expose a greater proportion of MCAS Beaufort to inundation caused by a Category 1 storm. This trend is especially clear in the eastern third of the installation. In the intermediate scenario, the area exposed to flooding increases to 45 percent by 2100; in the highest scenario, it increases to roughly 50 percent. In the highest scenario, the area of the base inundated by a Category 1 storm in 2100 is greater than the area inundated by a Category 2 storm today.

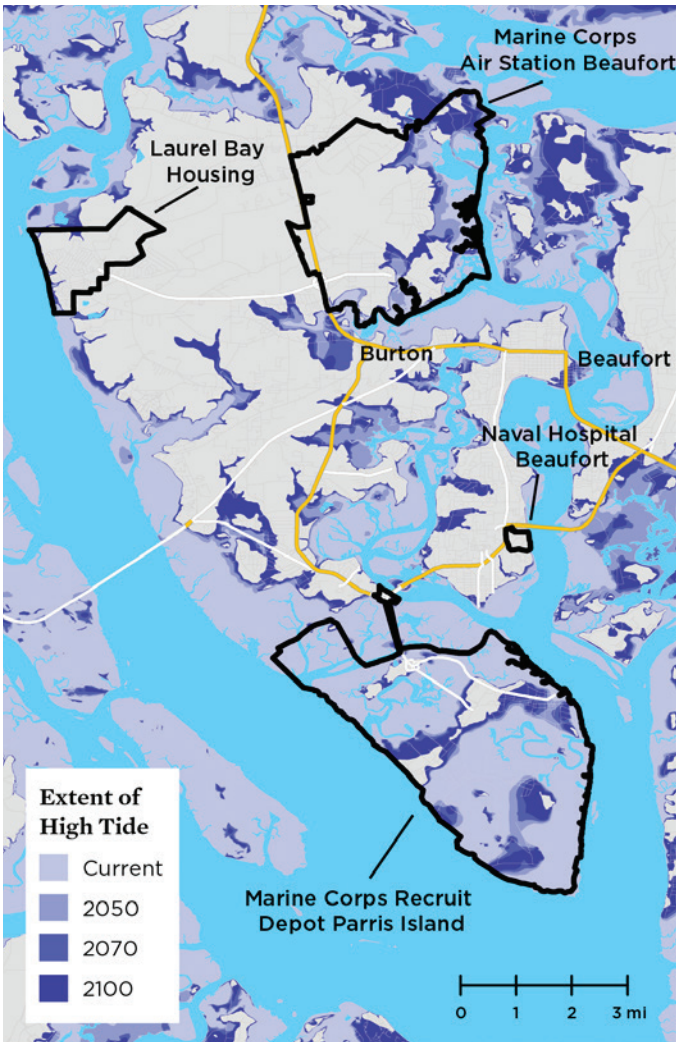
Sea level rise also changes the depth of flooding MCAS Beaufort can expect with major storms. Flooding from a Category 1 storm today would be less than 10 feet deep. By 2100 in the

TABLE 2. Current and Future Tidal Flooding Frequency around MCRD Parris Island and MCAS Beaufort

	Intermediate		Highest	
Year	Events per Year	% of Year	Events per Year	% of Year
2012	10 ± 7	0	10 ± 7	0
2050	152 ± 26	3	327 ± 38	8
2070	438 ± 38	13	671 ± 7	29
2100	698 ± 2	38	702 ± 4	62

MCAS Beaufort, with less low-lying land than MCRD Parris Island, will be less directly affected by tidal flooding. Shown here are flood events in low-lying areas projected by the intermediate and highest scenarios. As flood conditions begin to span multiple tide cycles, the rate of increase in distinct flood events slows, but the duration of flooding increases. Events per year are reported as the average over a five-year period with one standard deviation. Percent of year is reported simply as the average over a five-year period.

FIGURE 3. MCRD Parris Island Is Expected to Lose Currently Utilized Land



The projected reach of future daily high tides, shown above, encompasses currently utilized land at MCRD Parris Island, shown below. Mapped here is high tide in the highest scenario.

SOURCE: GOOGLE EARTH.

intermediate scenario, a Category 1 storm would expose nearly 15 percent of the installation to flooding 10 to 15 feet deep.

Today, a Category 4 storm would expose 70 percent of MCAS Beaufort to flooding. A Category 4 storm hitting in 2100 in the highest scenario is the worst-case scenario for the base in this analysis. More than 80 percent of MCAS Beaufort would be exposed to storm surge. Whereas a Category 4 storm today exposes about 17 percent of the installation to flooding 20 or more feet deep, that proportion doubles to 34 percent in the worst-case scenario.

Mobilizing on the Front Lines of Sea Level Rise

A vital trait of our nation's military is its ability to adapt in response to external threats. Climate change and sea level rise have emerged as key threats of the 21st century, and our military is beginning to respond (Hall et al. 2016; USACE 2015; DOD 2014). Local governments are also responding: In 2015, Beaufort County and multiple stakeholders published their Sea Level Rise Adaptation Report, and they have started preparing for rising seas (Beaufort County 2015).

But at MCRD Parris Island and MCAS Beaufort, and across US coastal installations, there is still far to go: the gap between the military's current sea level rise preparedness and the threats outlined by this analysis is large and growing. Low-lying federal land inundated by rising seas, daily high-tide flooding of more elevated land and infrastructure, and destructive storm surges—most of the installations analyzed, including MCRD Parris Island and MCAS Beaufort, face all of these risks.

This analysis provides snapshots of potential future exposure to flooding at these two installations, and it highlights the high level of exposure to hazards at MCRD Parris Island. For the Marine Corps to take additional action on the front line of sea level rise, however, it will need more detailed analysis and resources to implement solutions. Congress and the DOD should, for example, support the development and distribution of high-resolution hurricane and coastal flooding models; adequately fund data monitoring systems such as our nation's tide gauge network; allocate human, financial, and data resources to planning efforts and to detailed mapping that includes future conditions; support planning partnerships with surrounding communities; and allocate resources for preparedness projects, on- and off-site, many of which will stretch over decades.

Military bases and personnel protect the country from external threats. With rising seas, they find themselves on an unanticipated front line. Our defense leadership has a special responsibility to protect the sites that hundreds of thousands of Americans depend on for their livelihoods and millions depend on for national security.

ENDNOTES

1 *The intermediate sea level rise scenario assumes ice sheet loss that increases over time, while the highest scenario assumes rapid loss of ice sheets. The latter scenario is particularly useful for decisions involving an especially low tolerance for risk. These results are a small subset of the full analysis. For more information, the technical appendix, and downloadable maps, see www.ucsusa.org/MilitarySeasRising.*

2 *UCS analyzed storm surge depth and exposure extent for each installation using the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model, developed by the National Oceanic and Atmospheric Administration (NOAA), for storm events ranging in severity from Category 1 to Category 5, in addition to tidal floods. Both storm surge and flooding during extra-high tides can be significantly exacerbated by rainfall and wave action, neither of which was included in this study.*

3 *This analysis involved consultation with contacts at multiple installations. However, in some instances, preventive measures may be planned or in place that are not reflected in the analysis; these could affect the degree of current and future flooding.*

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