Union of Concerned Scientists

The US Military on the Front Lines of Rising Seas

Exposure to Coastal Flooding at US Coast Guard Station Sandy Hook, New Jersey

HIGHLIGHTS

Highlight: 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 on the East and Gulf coasts. Analysis for US Coast Guard (USCG) Station Sandy Hook found that in the second half of this century, in the absence of preventive measures, the installation 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 USCG Station Sandy Hook, New Jersey, 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 of Sandy Hook, seas are projected to rise between four 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 USCG Station Sandy Hook. 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 USCG Station Sandy Hook could be exposed, assuming no new measures are taken to prevent or reduce flooding.[3] This analysis finds the following key results:

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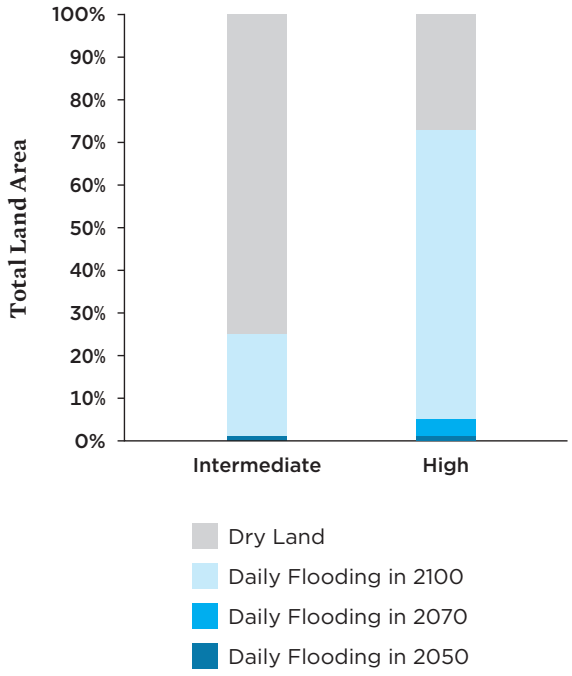
WILL RESCUE STATION NEED RESCUING?

USCG Sandy Hook, one of the oldest and most famous life-saving stations in the country, is located on the tip of a barrier spit (which is much like a barrier island, but connected at one end to the mainland). As sea level rises, USCG Sandy Hook's exposure to flooding from both high tides and storm surge is growing.

TIDAL FLOODING AND LAND LOSS

- **Areas currently affected by occasional tidal flooding could flood daily**. Certain low-lying areas of USCG Station Sandy Hook and the surrounding region are already affected by flooding during high tides more than 30 times per year on average. In the intermediate scenario, this flooding occurs more than 550 times per year by 2070—an average of more than once each day.
- **Flooding during extreme high tides will become more extensive**. Today, the station sees only small areas affected by flooding during extreme tides. But in the highest scenario, these tides encompass over half of the base and inundate access roads more than 30 times per year by 2070.
- **Extensive land loss at USCG Station Sandy Hook is possible**. Some parts of USCG Station Sandy Hook are projected to flood with such frequency by 2100 that they would effectively be part of the tidal zone as opposed to dry, usable land. Indeed, in the highest scenario, nearly three-quarters of the station's land area floods with daily high tides.

FIGURE 1. USCG Station Sandy Hook May Experience Major Land Loss



As high tide reaches farther inland, extensive land loss is possible at USCG Station Sandy Hook. Affected land may include developed and undeveloped areas and even wetlands that reside above the current high tide mark. The station is projected to see substantial loss of currently developed and utilized areas, particularly in the highest scenario.

STORM SURGE

- **Sea level rise exposes previously unaffected areas of USCG Station Sandy Hook to storm surge flooding**. In the intermediate scenario, the area exposed to storm surge flooding during a Category 1 storm in 2100 is equivalent to the area exposed to flooding by a Category 2 storm today.
- **Sea level rise exposes USCG Station Sandy Hook to deeper, more severe flooding**. By 2100 in the intermediate scenario, the area inundated by five feet or more of seawater during Category 1 storm surges increases from roughly 30 percent of the station today to roughly 80 percent.

Base Information

USCG Station Sandy Hook is situated within an East Coast hotspot, where natural subsidence, low-lying topography, and changing ocean circulation patterns contribute to above-average sea level rise (Sallenger, Doran, and Howd 2012). It is located at the northern tip of Sandy Hook, a barrier beach peninsula at the northern end of the New Jersey shore (NYHP 2016). The entire Sandy Hook peninsula, which is just one mile wide at its widest, is part of the National Park Service's Gateway Recreational Area.

Built in 1848, USCG Station Sandy Hook is one of the oldest and most famous life-saving stations in the country. The station became part of the Coast Guard in 1950 (USCG n.d). Today, USCG Station Sandy Hook houses response boats, Coast Guard cutters, and other life-saving vessels (USCG 2014). The station performs search and rescue operations and is responsible for law enforcement, environmental protection, and coastal security for regional waterways.

USCG Station Sandy Hook is an integral part of the regional economy, to which it contributes approximately 1,000 jobs, $67 million in labor income, and $83.5 million in gross

USCG Station Sandy Hook

Branch:	Coast Guard
Established:	1848
Size (Acres):	220
Active Duty:	70
Reserve:	50

SOURCE: USDHS AND USCG 2014.

domestic product (Lahr 2013). Seventy active duty and 50 reserve personnel are assigned to the station (USCG 2014).

Historic Exposure to Storm Surge and Flood Hazards

USCG Station Sandy Hook is highly exposed to storm surge today. A Category 1 hurricane exposes nearly 90 percent of the station to flooding related to storm surge. During Category 2 and stronger hurricanes, the entire station is exposed to flooding. Defenses including jetties, seawalls, and beach nourishment are used to protect the area (Monmouth County 2014).

There have been 22 hurricanes passing within 150 nautical miles of Sandy Hook since 1858 (NOAA n.d.), including Donna (1960), Felix (1995), Irene (2011), and Sandy (2012). Ten of these storms passed within 75 miles of the station.

Severe coastal flooding at Sandy Hook begins to occur when water levels reach 8.7 feet above the level of low tide. Hurricane Sandy set a new record in tide height at Sandy Hook, with water levels reaching 13.3 feet above the low tide line and waves that likely crested at 12 to 24 feet along the oceanfront. Hurricane Sandy caused $50 million in damage to the Coast Guard facilities (Sherman 2014). USCG vessels had to be relocated until facilities could be restored, affecting base mission and time-critical deployments (USDHS and USCG 2014). The Coast Guard also abandoned a number of housing units at the station that were damaged by Sandy, displacing about 30 families (Sherman 2014).

Future (Projected) Exposure to Storm Surge and Flood Hazards

SEA LEVEL RISE

The intermediate scenario projects that the Sandy Hook area will experience four feet of sea level rise and the highest scenario projects about 6.5 feet of rise by 2100. This rise will drive the high tide line inland and lead to increased exposure to different types of coastal flooding.

TIDAL FLOODING AND LAND LOSS

As sea level rises, routine tidal flooding is expected to become both more extensive and more frequent. Today, USCG Station Sandy Hook experiences very little flooding during extra-high tides. The intermediate scenario projects that, by 2100, extra-high tides could flood well over 60 percent of the station. In the highest scenario, roughly this same extent of flooding occurs by 2070.

UCS projections indicate that the frequency of tidal flooding at USCG Station Sandy Hook will increase steeply, jumping from an average of roughly 33 events per year today to roughly 260 events per year by 2050 in the intermediate scenario. In the highest scenario, low-lying locations experience roughly 680 events per year by 2070. With the highest scenario, flood-prone areas throughout the region could experience flooding with each of the two daily high tides and be underwater more than 40 percent of the time.

As sea level rises, the flooding that occurs in low-lying areas during high tides lasts longer. In the highest scenario, flood events in this area will begin to span many high tide cycles during the last quarter of this century. As a result, the number of individual flood events will decrease but the duration of flood conditions will increase until flooding is essentially constant and land that was once above the high tide line is permanently inundated. At Sandy Hook, the difference between high and low tide is small enough that flood conditions in some areas will eventually exist even at low tide. Indeed, in the highest scenario, USCG Station Sandy Hook's flood-prone areas are underwater about 90 percent of the year by 2100. Moreover, nearly three-quarters of the installation's land area would become part of the tidal zone by the end of the century, flooded by daily high tides (see Figure 3, p. 5).

TABLE 1. USCG Station Sandy Hook: Projected Sea Level Rise (Feet) in Two Scenarios

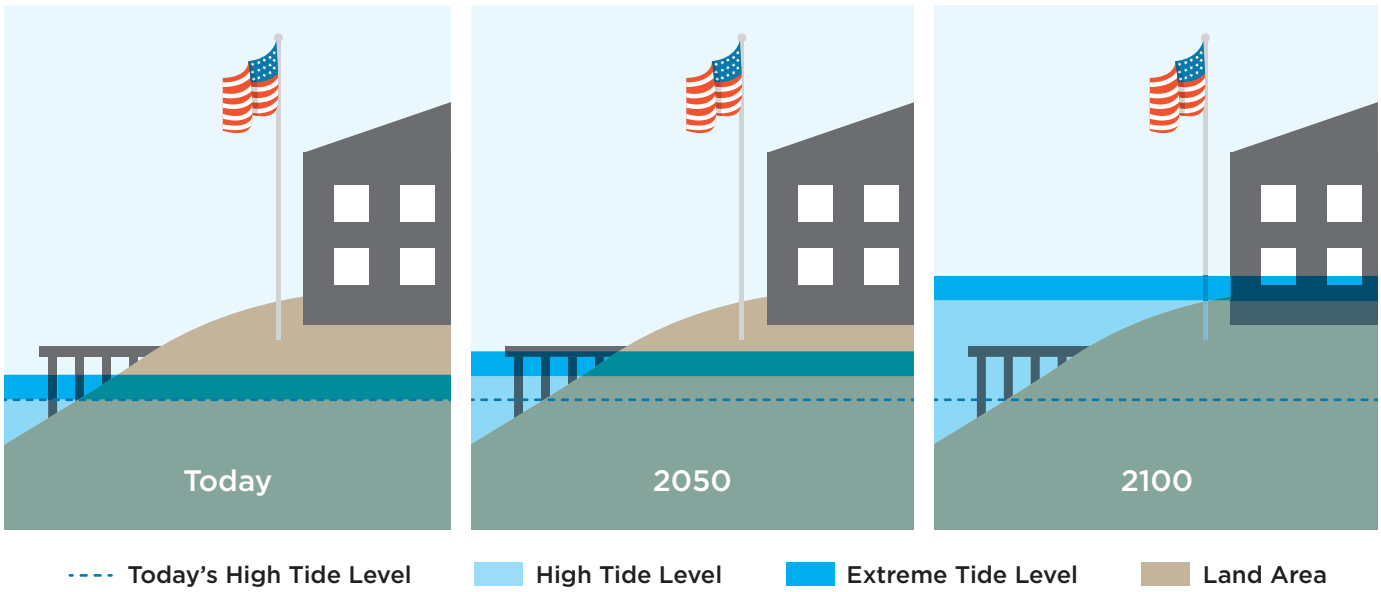
Year	Intermediate	Highest
2050	1.2	1.8
2070	2.1	3.3
2100	4.0	6.4

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 (DeConto and Pollard 2016; Trusel et al. 2015; Chen et al. 2013; Rignot et al. 2011). Values shown are local projections that include unique regional dynamics such as land subsidence (see www.ucsusa.org/MilitarySeasRising).

THE CHANGING THREAT OF HURRICANES

Category 1 hurricanes are the most likely type to affect this area.[4] Today, Category 1 storms expose about 90 percent of the station's area to flooding related to storm surge. In the intermediate scenario, that percentage rises just slightly by 2050 but rises to nearly 100 percent by 2100. In both the intermediate and highest scenarios, the area flooded by a Category 1 storm in 2100 is equivalent to the area flooded by a Category 2 storm today.

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.

Sea level rise also increases the depth of flooding USCG Station Sandy Hook can expect with major storms. A Category 1 storm would cause 31 percent of the station to experience flooding five feet or more deep today; in the intermediate scenario, the same storm occurring in 2100 would cause such flooding over 78 percent of the station.

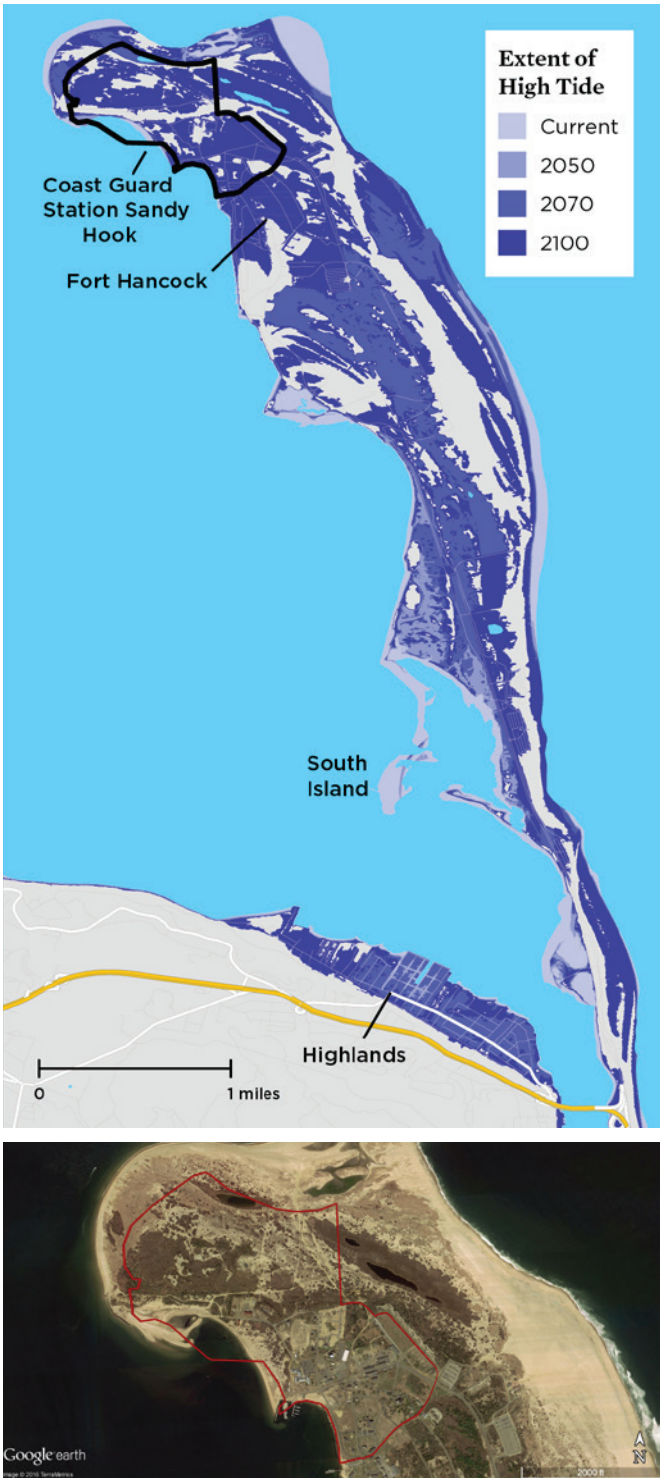
The worst case for Sandy Hook storm surge inundation considered in this analysis is a Category 4 storm occurring in the highest scenario. In that scenario, all of USCG Station Sandy Hook is exposed to flooding. And the flooding is deep. Today, a Category 4 storm exposes 53 percent of the base to flooding 20 or more feet deep. In the worst-case scenario,

TABLE 2. Current and Future Tidal Flooding Frequency at USCG Station Sandy Hook

	Intermediate		Highest	
Year	Events per Year	% of Year	Events per Year	% of Year
2012	33 ± 7	1	33 ± 7	1
2050	263 ± 24	7	471 ± 31	15
2070	562 ± 26	21	679 ± 34	41
2100	684 ± 33	52	254 ± 28	91

Projected sea level rise could lead to near-constant flooding of low-lying areas around USCG Station Sandy Hook. Shown here are flood events in flood-prone locations projected by the intermediate and highest scenarios. 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. As flood conditions span multiple high tide cycles, the number of distinct flood events drops, but the duration of flooding increases until it is nearly constant. Installations will be affected by this flooding depending on the presence of low-lying land on-site.

FIGURE 3. The Reach of Future Daily High Tides at USCG Station Sandy Hook



The projected reach of future daily high tides, shown above, encompasses currently utilized land at USCG Station Sandy Hook, shown on the bottom. The highest scenario is mapped here.

SOURCE: GOOGLE EARTH.

75 percent of the station could experience such flood depths in 2050 and more than 95 percent of the station in 2100.

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). After Hurricane Sandy, USCG Station Sandy Hook used disaster assistance funds to replace and repair damaged critical facilities to withstand a 500-year flood and to apply hurricane-resistant building codes (USCG 2014). Recognizing the threat of increased flooding at the USCG Station Sandy Hook, the coast guard is constructing new facilities above the 500-year flood plain where it considers this practical, as well as designing new structures for anticipated wave strength (Ingalsbe 2016).

But here 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 USCG Station Sandy Hook, face all of these risks.

This analysis provides snapshots of potential future exposure to flooding at USCG Station Sandy Hook. For the coast guard to take 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.*

4 *Nor'easters are more common in the region and known to generate damaging storm surge. As SLOSH models only hurricanes, we did not include lesser storms such as nor'easters in this analysis. Increases in surge extent and depth should be expected with these storms as well.*

REFERENCES

Chen, J.L., C.R. Wilson, and B.D. Tapley. 2013. Contribution of ice sheet and mountain glacier melt to recent sea level rise. *Nature Geoscience* 6(7):549-552.

DeConto, R.M., and D. Pollard. 2016. Contribution of Antarctica to past and future sea-level rise. *Nature* 531:591-597.

Department of Defense (DOD). 2014. Climate change adaptation roadmap. Washington, DC. Online at *http://ppec.asme.org/wp-content/uploads/2014/10/CCARprint.pdf*, accessed May 31, 2016.

Hall, J.A., S. Gill, J. Obeysekera, W. Sweet, K. Knuuti, and J. Marburger. 2016. *Regional sea level scenarios for coastal risk management: Managing the uncertainty of future sea level change and extreme water levels for Department of Defense coastal sites worldwide*. Washington, DC: US Department of Defense, Strategic Environmental Research and Development Program. Online at *www.serdp-estcp.org/News-and-Events/News-Announcements/Program-News/DoD-Report-on-Regional-Sea-Level-Scenarios*, accessed May 25, 2016.

Ingalsbe, J.K. 2016. Personal communication, May 13. Keith Ingalsbe works at USCG Station Sandy Hook.

Lahr, M. 2013. *New Jersey's military and coast guard facilities*. New Brunswick, NJ: Rutgers, the State University of New Jersey Edward J. Bloustein School of Planning and Public Policy. Online at *http://recon.rutgers.edu/wp-content/uploads/2014/03/NJ_Military_Missions_Economic_Impact2013.06.271.pdf*, accessed April 13, 2016.

Monmouth County. 2014. Multi-jurisdictional natural hazard mitigation plan—Monmouth County, New Jersey. Freehold, NJ: Monmouth County Office of Emergency Management. Online at *www.mcsonj.org/wp-content/uploads/2015/06/Hazmat%20Mitigation%20Plan%20-%201%20-%20REDACTED.pdf*, accessed April 11, 2016.

National Academy of Sciences (NAS). 2011. *National security implications of climate change for US naval forces: A report by the Committee on National Security Implications of Climate Change for US Naval Forces*. Washington, DC. Online at *www.nap.edu/download.php?record_id=12914*, accessed May 24, 2016.

National Oceanic and Atmospheric Administration (NOAA). No date. *Historical hurricane tracks*. Washington, DC. Online at *https://coast.noaa.gov/hurricanes/*, accessed March 23, 2016.

New York Harbor Parks (NYHP). 2016. Sandy Hook. Online at *www.nyharborparks.org/visit/saho.html*, accessed March 14, 2016.

Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. *Global sea level rise scenarios for the National Climate Assessment*. NOAA tech memo OAR CPO-1. Washington, DC: National Oceanic and Atmospheric Administration. Online at *http://scenarios.globalchange.gov/sites/default/files/NOAA_SLR_r3_0.pdf*, accessed April 25, 2016.

Rignot. E., I. Velicongna, M.R. van den Broeke, A. Monaghan, and J.T.M. Lenaerts. 2011. Acceleration of the contribution of the Greenland and Antarctic ice sheets to sea level rise. *Geophysical Research Letters*, doi: 10.1029/2011GL046583.

Sallenger, A.H., K.S. Doran, and P.A. Howd. 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America. *Nature Climate Change* 2:884–888. doi:10.1038/nclimate1537.

Sherman, T. 2014. Coast guard and NJ National Guard still feeling effects of Sandy, two years after the storm. *Star-Ledger*, August 17. Online at *www.nj.com/news/index.ssf/2014/08/coast_guard_and_nj_national_guard_still_feeling_effects_of_sandy_two_years_after_the_storm.html*, accessed April 11, 2016.

Trusel, L.D., K.E. Frey, S.B. Dias, K.B. Karnauskas, P. Kuipers Munneke, E. van Meijgaard, and M.R. van den Broeke. 2015. Divergent trajectories of Antarctic surface melt under two twenty-first-century climate scenarios. *Nature Geoscience* 8:927–932. doi:10.1038/NGEO2563.

US Army Corps of Engineers (USACE). 2015. *North Atlantic Coast comprehensive study: Resilient adaptation to increasing risk*. Brooklyn, NY. Online at *www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS_main_report.pdf*, accessed May 25, 2016.

US Coast Guard (USCG). No date. *Station Sandy Hook, New Jersey, USLSS Station #1, Fourth District, Coast Guard Station #97*. Norfolk, VA. Online at *www.uscg.mil/history/stations/SANDYHOOK.pdf*, accessed June 14, 2016.

US Coast Guard (USCG). 2014. *Draft environmental assessment: Recapitalization project USCG Station Sandy Hook New Jersey*. Norfolk, VA. Online at *www.uscg.mil/d5/publicnotice/SHook_PublicDEA_081514_email_version.pdf*, accessed April 11, 2016.

US Department of Homeland Security and United States Coast Guard (USDHS and USCG). 2014. Recapitalization project USCG Station Sandy hook New Jersey. Online at *www.uscg.mil/d5/publicnotice/SHook_PublicDEA_081514_email_version.pdf*, accessed June 23, 2016.

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