DEEP SEA RISING: Challenges in the Pacific

While military installations in the Pacific stand ready to defend the United States and its allies, their future stability is threatened by sea level rise.

By Vladimir Moya Quiroga Gomez, Dr. Eng.

The Pacific theater is a complex region where America's vital interests are at stake. Most U.S. trade passes through the region; five of seven treaty allies are in the Asia-Pacific; and four nuclear-armed nations ring the world's largest ocean.

The ability to project power is crucial to national defense. In addition to Alaska, Hawaii, Washington, Oregon, and California, there are several American territories and commonwealths, and other military installations in the Asia-Pacific, including Guam, the Northern Marianas Islands, American Samoa, Wake Island, Japan, Korea, and Australia. Such installations protect not only the United States, but also its allies.

ISOLATED LOCATIONS

The remoteness of military installations in the Pacific means that materials and services are more costly to procure and maintain. Their location also makes them highly vulnerable to natural disasters such as typhoons, tsunamis, storm surge and flooding.

Besides these current challenges, future climatological conditions may increase the risk of natural disasters or create even new concerns, principally sea level rise. The most recent *National Defense Authorization Act* places the Department of Defense at the forefront of dealing with sea level rise. This may be out of necessity due to the tropical and subtropical latitudes of Pacific-based installations, and the fact that most of them are on islands surrounded by ocean.

Whether sea level rises a few centimeters or more than 1-m, the point is that sea levels will rise and actions must be taken. Just a couple centimeters may be the difference between freshwater being contaminated by salt intrusion or a flood defense overflowing, causing social, environmental, and economic losses, and potentially impacting critical missions.

SEA LEVEL CHANGES

Changes in sea level occur over a broad range of temporal and spatial scales. The primary contributors to contemporary sea level change are the expansion of the ocean as it warms, and the transfer of water currently stored on land to the ocean, particularly from land ice.

Thermal expansion is caused when seawater expands because of the higher temperature of the water. Since the oceans absorb heat from the atmosphere, when the atmosphere becomes warmer so will the oceans. Warm seawater has a greater volume than cold seawater. Therefore, as the temperature of the ocean increases, so will the total ocean volume. The increased volume forces the level of the water to rise. The magnitude of this increase depends on the vertical and the latitudinal distribution of warming in the ocean. Projections suggest the likely range of global mean sea level rise within the 21st century will be between 0.4-m and 1.0-m—but some estimations go even higher.

While it is commonly assumed sea level rise will be uniform, instead, regional sea level changes may differ substantially from a global average. Complex spatial patterns, resulting from ocean dynamics, heat transport, movements of the sea floor, different sun exposure, and changes in gravity due to water mass redistribution, can lead to fluctuations in sea level rise. For example, the 1993-2001 sea level rise in the Japan/Korea region was nearly twice the global mean sea level rise trend.

Military installations in Guam, Okinawa, and Japan may experience up to more than 1-m sea level rise. Some worst-case scenarios suggest that sea level rise by the end of the century could even be as high as 2-m.

According to the Intergovernmental Panel on Climate Change, the Asia-Pacific is expected to experience the highest sea level rise. Military installations in Guam, Okinawa, and Japan may experience up to more than 1-m sea level rise. Some worst-case scenarios suggest that sea level rise by the end of the century could even be as high as 2-m.

For Asia-Pacific installations, sea level rise can lead to salt intrusion, beach loss, and storm surge.

SALTWATER INTRUSION

Saltwater intrusion has been recognized as a major impact of sea level rise. Higher sea levels promote sea water intrusion into river

Pacific-based installations that are situated in the middle of the ocean (such as Wake Island, a strategic refueling stop for military aircraft located 1,500-mi east of Guam) are more vulnerable to natural disasters including typhoons, tsunamis, storm surges, and flooding. U.S. MARINE CORPS PHOTO BY CPL. FRANCISCO J. DIAZ JR.

estuaries and aquifers, causing degradation of freshwater resources as well as diminishing the bearing capacity of soil. This is more evident in smaller islands like Okinawa, Ie-Jima, and Guam.

Small islands usually depend on groundwater pools called freshwater lens. The freshwater lens is floating on heavier sea water filled in porous coral islands. This difference in water density plays an important role because the interface between the heavier sea water and the overlying fresh water is pushed 40-ft below sea level for every foot that the water table stands above sea level. Every foot of sea level rise therefore means the freshwater-saltwater interface moves about 40-ft.

Additionally, small islands usually rely on groundwater extraction as a freshwater source. The combined effects of sea level rise and water table decrease (due to groundwater drawing) may result in saltwater intruding into the freshwater system. Such intrusion would not only damage the freshwater reservoirs for human consumption, it also would destroy vegetation and plantations relying on groundwater. The communities of freshwater plants and fish may die out due to the extension of salt wedge intrusion.

Guam provides a valuable history lesson. Research shows the chloride concentration in the Northern Guam Lens Aquifer between 1974-2005 increased 70 percent. Being that chloride is the customary index of groundwater salinity, this trend indicates that salinity is increasing. Such salinity trends combined with an increased water demand due to the 5,000 U.S. Marines to be relocated to Guam has led to concern over the sustainability of withdrawals from existing and proposed wells, and assurance of freshwater availability.

STORM SURGE CONCERNS

Climate change will affect sea level extremes and storm surge events in two principal ways. First, because extratropical and tropical storms are one of the key drivers of sea level extremes and ocean waves, future changes in intensity, frequency, duration, and path of these storms will be impactful. Second, sea level rise adds to the heights of sea level extremes, regardless of any changes in the storm-related component.

A surge forms when strong winds over the ocean combine with low pressure to drive water onshore. Storm surges can produce sea levels much higher than normal high tide. This leads to extreme coastal and inland flooding. Storm surges can cause tremendous damage if they coincide with high tide.

Storm surges are common events in Japan. A study led by the University of Tokyo suggests that sea level rise may increase storm surge in such a magnitude that the Tokyo Bay would be affected with potential direct costs in excess of 100 trillion yen (about $1 trillion). The location area of U.S. Fleet Activities Yokosuka is at considerably high risk of storm surges and sea level rise. Japan is considering protective measures including the strengthening of sea defences or a storm surge barrier. The United States should evaluate similar protections as well.

THE TIME TO ACT

Already the Pacific theatre is complex due to geopolitical trends. Sea level rise may cause severe impacts to military installations. The United States cannot risk even more precarious situations.

We must identify potential problems for each installation and define the priorities, as not all sectors will require the same level of investment. Then, we will be able to prepare and implement appropriate adaptation and mitigation strategies.

TME

Vladimir Moya Quiroga Gomez, Dr. Eng., is Civil Engineer – Numerical Modeler, Environmental Science Corp.; vladimir.gomez@kankyoscience.com.