CHESAPEAKE ENVIRONMENTAL PROTECTION ASSOCIATION, INC.
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**NEWSLETTER** **Fall 2017**

## PRESIDENT'S MESSAGE

*By Al Tucker*

### CLIMATE CHANGE AND THE CHESAPEAKE BAY

In this issue we address some of the key challenges facing us with climate change. Climate change is associated with global warming, and a hotter planet implies that the Greenland Glaciers and the Antarctic ice cap will melt, causing the seas to rise and inundate the coastal areas with several tens of feet of water. Fortunately, this climate change scenario is not imminent, but for the sake of future generations we should not ignore it.

There is a great deal of uncertainty associated with future projections. Those of you who have watched the recent hurricane predictions are familiar with the cone of uncertainty that gets larger as the time horizon is extended. There is a high degree of agreement among models in the near future, but they tend to diverge as the time horizon is extended. Yet, the average of the models tends to be fairly accurate. Just by looking out the window, we are all pretty good weather prognosticators when it comes to the next hour. But we rely on the weather forecaster, if we are going to have a picnic.

However, the impacts of climate change are far more subtle, almost imperceptible, and seem to defy our ability to realize the changes that have occurred. These effects may be far more devastating and costly than we realize. When we try to understand the impacts of climate change, we are overwhelmed by the flood of information about seemingly unrelated effects that reach deeply into everyday lives. How do we make sense of it? How will it affect us? And then what should we do? To answer these questions, I will look closer to home, to the Chesapeake Bay, and hopefully relate <u>some</u> of the observed and projected consequences that are related to climate change. I underline "some" since there are a large number of them. I will choose those that I perceive to have the most impact, especially those that hit us in the pocketbook.

Over a century ago, a Swede, Svante Arrhenius, anticipated global warming. He was trying to understand what caused the ice ages. His calculations presage what more sophisticated calculations today estimate. He predicted that, if the carbon dioxide doubled its present value, the average temperature on earth would increase by 9-11°F. Since Arrhenius' time, atmospheric carbon dioxide has increased by factor of 1.3 and the global average temperature has increased by only 1.4°F. The average temperature of the Arctic, though, has increased more rapidly, by almost 5°F, closer to what Arrhenius predicted.

**IN THIS ISSUE**



Since we live in the mid latitudes, these observations are not perceptible on an everyday basis. By 2050 the expected number of 95°F days here in Maryland will increase by about 15, but the number of freezing days will drop by 30 days. This is because the average nighttime temperature increase is the main contributing factor of the 3.5°F increase of the daily average for Maryland over the last century[i]. Since this occurs when we are asleep, it escapes our perception. As Arrhenius postulated, the increase in carbon dioxide acts like a blanket at night by keeping the heat trapped. This heat is being trapped by the ocean, causing water to expand in volume, increasing sea level by an imperceptible eighth of an inch per year. In the past 85 years, Anne Arundel County has seen about a foot of sea level rise. Up to now, thermal expansion of the ocean has been the major contributor to the rise. But even this relatively small increase leads to nuisance flooding at high tides. The surprise – of the top ten US areas with nuisance flooding, Annapolis holds the record with the largest number of days – 40. For most of us that is an inconvenience, but for downtown shopkeepers it is an increasing threat and an economic cost.

So how does this change affect us? A general perception exists that climate change has not impacted us economically. Whereas climate scientists have long agreed on the physical impacts of global warming, climate economists have not really contributed much about economic impacts. In a recent paper[ii], more than 50% of the climate economists surveyed thought that agriculture, fishing, forestry, real estate, insurance and health services would be impacted negatively. Only 40% felt that the negative impacts are occurring now, but more than 90% felt that climate change will damage the global economy by mid-century.

As we have learned from our most recent hurricanes and tsunamis, it is the storm surge that causes the damage and loss of life. An imperceptibly small increase in sea level becomes amplified along shorelines and within embayments and tributaries. Locally, our most recent experience with storm surge was in 2003 with Hurricane Isabel. The peak storm surge reached over 8 ft. in the Bay. In Anne Arundel County, FEMA estimated the total damage to be $651M (2017 dollars). The Naval Academy infrastructure was severely damaged, and the Annapolis Maritime Museum was under 6 ft. of water. Two of the largest wastewater treatment plants in Prince Georges County lost power, resulting in 96M gallons of wastewater being dumped into the Patuxent River. Subsequent storm surge projections for the Bay for a Category 4 storm hitting the Carolinas indicate that we can expect up to a 14-18 ft. surge in the upper reaches of the Bay. For a storm surge of 6 ft. in Anne Arundel County, 13,000 people, 6,000 homes with a value of $3.4B and 2 hazardous waste sites will be at risk. The likelihood of such a storm hitting us is projected to be between 10 - 19% by 2030 and 25 - 84% by 2050. From a mathematical viewpoint this is not a negligible risk. This year three Category 4 storms struck the US, so the risk of one striking our region is real. In fact, NOAA just released figures for the increase in billion dollar (or more) weather related disasters. From 1980 to 2007, we averaged 4 events per year; since 2007 we have averaged 11 per year[iii]. (Note: these figures do not include the recent hurricanes with estimated costs of over $21B.)

What should we do? We should determine the personal level of risk we face and what we can tolerate. Then, for each individual situation, develop a plan for adapting to the most probable outcome. The question is not "if" but "when" it will happen.

To find how you will be affected, the website: [riskfinder.org](riskfinder.org) presents an interactive map that shows you how a storm surge could impact you. In 2011 Anne Arundel County did a very good analysis[iv] of the areas in the county to show the impact of storm surges. From there you can assess your own personal level of risk. If you live in Eastport, another very good assessment[v] will show you the impacts there. Since these reports have been done, very little action has been taken to lessen damage from storm surge in our vulnerable communities. I presume the reason is the costs associated with their implementation.

In 2007, the Maryland Climate Change Commission[vi] (MCCC) was established by executive order. In 2015, the General Assembly codified its mission into law to advise the Assembly and the Governor "on ways to mitigate the causes of, prepare for, and adapt to the consequences of climate change". The best line of defense in the future, of course, is mitigation, that is, eliminating the causes, namely greenhouse gases. Maryland along with eight other Northeast states formed the Regional Greenhouse Gas Initiative. Since 2005 this effort has reduced greenhouse gases by 40% in these states.

Everyone needs to consider limiting their carbon footprint. The MCCC has produced a series of guides for individuals, businesses, and local governments for mitigation and adaptation practices[vii]. Maryland has been a leader in climate change planning and mitigation. Adaptation, though, remains the purview of local governments

Even with an abrupt cessation of carbon dioxide emissions, it will take centuries for the planet's ecosystems to rebalance. So every little bit of reduction that each of us can contribute counts and will help reduce the uncertainty facing future generations.

[i] Rising temperatures in the last century. Except for western Maryland, the state has warmed more than most of the nation. Source: EPA, Climate Change Indicators in the United States.
[ii] "Expert Consensus on the Economics of Climate Change", Institute for Policy Integrity, New York University School of Law, (Dec. 2015)
[iii] Billion-Dollar Weather and Climate Disasters: Table of Events, noaa.gov/billions/events/US/1980-2017
[iv] Sea Level Rise Strategic Plan Anne Arundel County, AASLRStrategicPlan_final.pdf
[v] Flood And Inundation Mitigation Strategies City Of Annapolis, Maryland Eastport Area, http://dnr.maryland.gov/ccs/Publication/Annapolis_FIMS_eastport.pdf
[vi] Maryland Climate Change Commission; MDClimateChangeCommision
[vii] Maryland Climate Change Guides: climatechange.maryland.gov/what-can-you-do/



## THE ANTARCTIC AND SEA LEVEL RISE

*By Gary Antonides*

Antarctica is the highest, driest, coldest, and windiest of the seven continents. It is roughly the size of the United States and Mexico combined and is almost completely covered by a layer of ice that averages more than one mile in thickness, but is nearly three miles thick in places. This ice accumulated over millions of years through snowfall. Presently, the Antarctic ice sheet contains 90% of the ice on Earth and would raise sea levels worldwide by over 200 feet were it to melt. This description of Antarctica is found on https://lima.nasa.gov/antarctica/

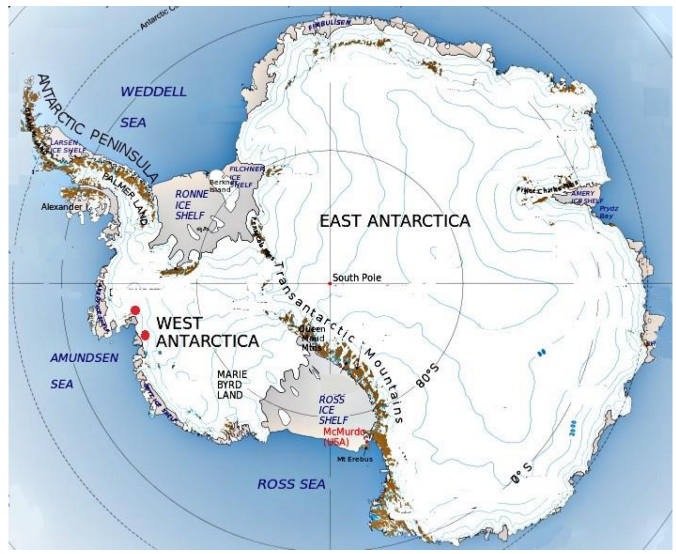


Figure 1

Antarctica is made up of three regions. The 2000-kilometer Transantarctic Mountains separate the continent into a large sector in the east called East Antarctica, and a smaller sector in the west called West Antarctica. The Antarctic Peninsula is the most northerly region and is primarily a second mountain range. The East Antarctic ice is typified by vast flat areas of polar desert, where it is too cold for much snow to fall, and frigid winds blow continuously. The West Antarctic ice sheet rests on a bed well below sea level and is drained by large outlet glaciers and ice streams that flow for hundreds of kilometers before reaching the ocean, often through large floating ice shelves.

The ground beneath the Antarctic ice sheet is a mixture of mountains, plains, and ocean basins. The tallest mountains extend above the ice sheet, the highest being 4,897 meters above sea level. The deepest known ice rests 2,555 meters below sea level, where the ice is over 4 kilometers thick. Gravity exerts sufficient force on the ice that the ice sheet moves. Flow rates increase toward the coast as faster moving glaciers are formed. Some glaciers flow into the ocean while others form large, thick floating ice shelves. The Pine Island Glacier (see upper red dot in Figure 1), flowing at over 10,000 feet per year, is believed to be the fastest Antarctic glacier. The largest ice shelf is the Ross Ice Shelf, roughly the size of Texas.

When talking about sea level rise, Antarctica must be considered since it contains about 90% of the world's ice, and, if it all melted, sea level rise would be about 200 ft. That won't happen, but the ice *is* melting, and we need to anticipate how much. The science involved is still a work in progress.

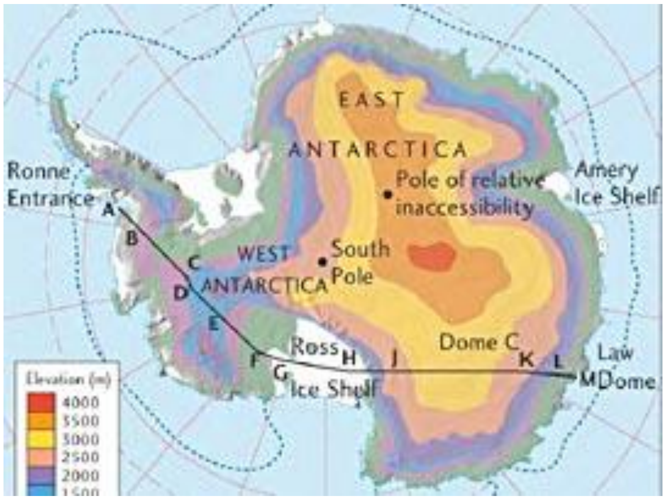


Figure 2. The elevation of the ice sheet shows the higher dome of the East Antarctic ice sheet.

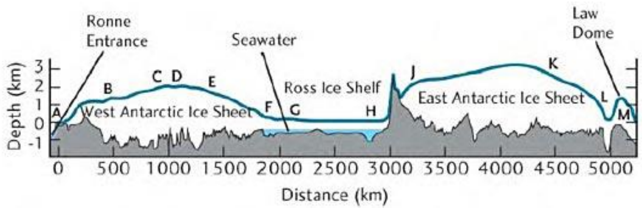


Figure 3. A vertical cross-section through Antarctica shows that the East Antarctic ice sheet is much higher than the West Antarctic ice sheet. Note that most of the ground along the cross section is below sea level but ice prevents the sea from intruding.

http://www.nationalgeographic.com/magazine/2017/07/antarctica-sea-level-rise-climate-change/ describes some of the recent studies with a disturbing headline: *"The Larsen C Ice Shelf Collapse Is Just the Beginning—Antarctica Is Melting. The massive iceberg that broke off the Larsen C Ice Shelf may be a harbinger of a continent-wide collapse that would swamp coastal cities around the world."* The story, by Douglas Fox, appeared in the July 2017 *National Geographic*, and was updated on line when a Delaware-sized iceberg broke off the Larsen C ice shelf. This does not raise sea levels since the ice shelf was floating, but ice shelves hold back glaciers that, when they reach the ocean and calve, do raise sea levels.

**Antarctic Peninsula**. Average warming here has been far greater than elsewhere on the continent. That explains why the huge iceberg broke off the Larsen C Ice Shelf and why, since 1988, four ice shelves on the east side of the peninsula have completely disintegrated into icebergs in the Weddell Sea. The Larsen C Ice Shelf may one day also disappear. Catching the winds and ocean currents that swirl around Antarctica, the peninsula gets slammed with warm air and water from farther north. Average temperatures on its west side have risen nearly 5ºF since 1950, several times faster than the rest of the planet. Winters have warmed an incredible 9ºF. Sea ice now forms four months a year instead of seven.

Warmer air helped trigger these collapses by forming meltwater ponds on the surface of ice shelves. The ponds drained into crevasses, making them deeper. As the shelves have vanished, the glaciers they once stabilized have accelerated to as much as nine times their original speed. They're relatively small glaciers and won't raise sea level much, but it raises concerns that the same thing might happen to the much larger glaciers along the Amundsen Sea.

**Pine Island Glacier.** The Amundsen Sea lies a thousand miles to the southwest. The larger glaciers there, including the Pine Island Glacier, make the stakes far higher. Pine Island Glacier (upper red dot in Figure 1) is held back by the Pine Island Ice Shelf which is buckled and scarred by thousands of large crevasses. In 2015 and 2016 a 225-square-mile chunk of it broke off into the Amundsen Sea. The water there has warmed by more than 1ºF over the past few decades, and the rate at which ice is melting and calving has quadrupled. The Pine Island Ice Shelf, about 1,300 feet thick over most of its area, thinned by an average of 150 feet from 1994 to 2012.

The Pine Island Glacier is one of several large glaciers that empty into the Amundsen Sea and drain a much larger dome of ice, the West Antarctic Ice Sheet, which is up to two and a half miles thick and covers an area twice the size of Texas. The ice sheet is draped over a series of islands, but most of it rests on the floor of a basin that dips more than 5,000 feet below sea level. That makes it especially vulnerable to the warming ocean. If all that ice were to break into pieces, and float away, as researchers increasingly believe it might, it would raise sea level by roughly 10 feet.

In December 2012, a Twin Otter plane landed on the Pine Island Ice Shelf, being very careful to avoid snow covered crevasses. A research team led by glaciologist Martin Truffer of the University of Alaska got out of the plane and set up camp, planning to spend two months on the ice shelf. No one had spent even a single night before. They wanted to bore holes all the way through the ice shelf and measure the heat eating at it from the seawater below. As they lay in their tents at night, they heard loud pops and bangs coming from the ice. Each morning they saw new cracks. During their five weeks there, the ice thinned by seven feet.

It has been very difficult for research ships to get close to West Antarctica's glaciers. In summer, in front of the ice shelves, fractured sea ice joins icebergs calved from the ice shelves. That normally keeps ships at least 100 miles from the ice shelf. However, in March 1994, the U.S. research icebreaker *R/V Nathaniel B. Palmer* became perhaps only the second vessel ever to reach it. For a few days winds parted the ice floes, creating a narrow passage. Sonar showed a chaotic seafloor of canyons and sharp ridges. The *Palmer* would spend just 12 hours by the ice shelf before encroaching sea ice forced it to retreat. But that gave the crew enough time to make a disturbing discovery. Near the surface, a current was streaming out from under the ice shelf that was less salty than the sea around it because it was freshened by melted ice. And at depths of 2,000 to 3,000 feet, in a seafloor canyon that ran under the ice, warmer seawater was streaming in.

The warm water was coming from the South Pacific more than 200 miles north. It was heavy with salt so it was following the floor of the submarine canyon. The glacier itself had carved that canyon during the Ice Age, when it reached hundreds of miles out from its present-day position. Tens of miles inland, the warm water was finding the "grounding line": the place where the glacier lifts off the seafloor. Hitting that wall of ice, the warm water was melting it, producing a steady stream of less salty seawater, which, being less dense, rises above the incoming water and flows back out to sea just under the shelf.

By measuring the amount of this freshwater, the researchers estimated how much ice was being lost. Adrian Jenkins, a glaciologist from the British Antarctic Survey in Cambridge, calculated that the ice shelf was losing an incredible 13 cubic miles of ice per year from its underside. Near the grounding line, the ice was probably thinning up to 300 feet per year.

Over the next 13 years Jenkins tried three times to return to Pine Island, but sea ice blocked him. When the *Palmer* got back there in 2009, the melt rate had increased by about 50%. This time they came with a robotic submarine. On its first three dives, it discovered that the ice shelf had thinned enough to lift off a submarine ridge that had once supported and stabilized the ice shelf. That had opened a gap that was allowing warm water to flow in and melt the underside of the ice even faster.

The sub's sonar revealed that the bottom of the ice shelf was corrugated with many channels that cut as far as 600 feet up into it, and along the ceiling of each ran a gaping crack. These upside-down canyons had been carved by flowing water. The meltwater rising off the grounding line was still warm enough to melt more ice as it flowed for tens of miles along the underside of the ice shelf back out to sea.

The Amundsen Sea is farther south than the peninsula, and the air there is not as warm. The biggest threat to its glaciers is these deep submarine canyons that channel warm water from the north under the ice shelves, and the deep inverted canyons that warm the underside of the ice.

Last November, Ian Howat, of the Byrd Polar and Climate Research Center in Ohio, reported two new rifts spreading across the Pine Island ice shelf that threaten to prune it to its shortest length in recorded history. The "warm" water flowing underneath it from offshore is 4 to 6ºF above freezing. As the Pine Island Ice Shelf has weakened and the glacier behind it has accelerated, the ice has stretched and thinned for 150 miles inland from the coast. The destabilizing effects spread farther into West Antarctica every year.

**Other West Antarctic Glaciers.** Research over the past few years indicates that the collapse of several major glaciers flowing into the Amundsen Sea is now unstoppable. Between 2002 and 2009 alone, the ice shelf in front of the Smith Glacier thinned by 1,500 feet in some places, the one in front of the Pope Glacier by up to 800 feet. The grounding lines of the Amundsen glaciers have retreated tens of miles in some cases. Each increment of retreat exposes a greater ice surface to warm ocean water. It's a runaway process—and scientists are urgently trying to figure out how fast it will proceed.

Most worrisome is the Thwaites Glacier (the lower red dot in Figure 1), which could destabilize most of the West Antarctic Ice Sheet if it collapsed. By itself it could raise global sea level four feet. Last fall the British and American science foundations announced a coordinated $20 million to $25 million field campaign that will deploy ships, planes, satellites, and underwater robots to assess the glacier's status.

"These are the fastest retreating glaciers on the face of the Earth," says Eric Rignot, a glaciologist at the NASA Jet Propulsion Laboratory in Pasadena, California. He believes the collapse of the West Antarctic Ice Sheet is only a matter of time. It may take 500 years or it may take less than a hundred.

**Totten Glacier.** To consider the long term worst case, we must consider East Antarctica, home to more than three-fourths of all the ice on Earth. This past January an old DC-3 from Australia's Casey Station made a series of flights along the East Antarctic coast. Over the Totten Glacier, a radar recorded the thickness of the ice. Another instrument found the topography of the seafloor under the glacier's floating ice shelf.

Until recently the East Antarctic Ice Sheet was considered secure. Much of it sits on high ground, but mapping with the ice-penetrating radar has revealed a low-lying region cut by glacially carved channels that drop as far as 8,500 feet below sea level. This is perfect for guiding warm ocean water deep into the heart of the ice sheet. The Totten Glacier is the largest coastal outlet in this region. If it collapsed, global sea level could rise 13 feet, just from that one glacier.

In 2015, the Australian icebreaker *Aurora Australis* became the first ship to reach the front of Totten. Like the *Palmer* at Pine Island in 1994, it found deep, warm water flowing under the ice shelf. The glacier is already losing a couple of cubic miles of ice per year. That's not much in Antarctic terms, but there is concern that it could increase dramatically. Totten will lose its ice much more slowly than West Antarctica. The worst case regarding sea level rise still seems to be centuries away.

**Other Surveys.** A satellite survey last year of many Antarctic ice shelves led by Ted Scambos of the National Snow and Ice Data Center in Colorado, and Helen Fricker of the Scripps Institution of Oceanography in San Diego revealed that melt canyons are common. They tend to steer water toward the edges of the shelves making the ice there thinner than the rest of the shelf. The ice there is crucial because it rubs against the stationary banks and slows the flow of the shelf and the glacier behind it. Fricker and her team have found that from 1994 to 2012, the amount of ice disappearing from all Antarctic ice shelves increased 12-fold, from 6 cubic miles to 74 per year.

**Predictions.** Sea level rise may not be disastrous for the next 30 to 40 years, but from 2050 to 2100 things could be different. The heat now hitting the Antarctic ice shelves comes from intensified circumpolar winds and currents driving water from further offshore onto the continental shelf and under the floating ice. That water is warmer than more local water, and the ocean in general is warming. These effects will continue to melt ice even if we begin to cut emissions.

For now, the best estimates suggest that Antarctica will melt enough ice to raise global sea levels by 1.5 to 3.5 feet by 2100. With Greenland and other rapidly melting glaciers around the world, average sea levels could rise 3 to 7 feet by 2100. But sea level won't stop rising in 2100. A complete collapse of the Greenland and West Antarctic Ice Sheets would raise sea level only about 35 feet, but if the East Antarctic Ice Sheet melts, the rise will be well over 200 feet.

Predictions of sea level rise due to glaciers melting cannot be reliable until the science is better understood and good models developed. An example of the type of difficulties in developing models is the study of sea ice in the Antarctic, which should be a simpler problem to assess. It is discussed in the next article.

## Antarctic Sea Ice Variability

Bill Klepczynski & Al Tucker

Sea ice keeps the Polar Regions cool and helps moderate global climate. Sea ice has a bright surface; 80 percent of the sunlight that strikes it is reflected back into space. As sea ice melts in the summer, it exposes the dark ocean surface and the ocean absorbs 90 percent of the sunlight. The oceans heat up, and temperatures in the Polar Regions rise further.

According to scientific measurements, both the thickness and extent of summer sea ice in the *Arctic* have shown a dramatic decline over the past thirty years. However, sea ice in the

*Antarctic* region has not. The loss of Arctic sea ice will potentially accelerate global warming and change climate patterns.

Sea ice extent is a measure of the area of ocean where there is at least some sea ice. It forms, grows, and melts in the ocean. In contrast, icebergs and ice shelves float in the ocean but originate on land. For most of the year, sea ice is typically covered with snow. Usually, scientists define a threshold of minimum concentration to mark the ice edge; the most common cutoff is at 15 percent because it provides the most consistent agreement between satellite and ground observations.

The sea ice surrounding Antarctica has increased in extent and concentration from the late 1970s, when satellite-based measurements began, until 2015. This increase is not reproduced by climate models, and comes despite the overall warming of the global climate and the region. Although this increasing trend is modest, it is surprising given the overall warming. Indeed, climate models, which incorporate our best understanding of the processes affecting the region, generally simulate a decrease in sea ice. Moreover, sea ice in the Arctic has exhibited pronounced declines over the same period, which *is* consistent with global climate model simulations. For these reasons, the behavior of Antarctic sea ice has presented a conundrum for global climate change science.

Antarctica and the Arctic react differently to climate change partly because of geographical differences. Antarctica is a continent surrounded by water, while the Arctic is an ocean surrounded by land. Wind and ocean currents around Antarctica isolate the continent from global weather patterns, keeping it cold. In contrast, the Arctic Ocean is affected by the climate around it, making it more sensitive to climate changes.

The National Academies of Sciences, Engineering, and Medicine held a Workshop on January 11-12, 2016, in Boulder, Colorado, to bring together scientists with different sets of expertise and perspectives to further explore the mechanisms driving the evolution of recent Antarctic sea ice variability and to discuss ways to advance understanding of Antarctic sea ice and its relationship to the broader ocean-climate system.

There are many local, regional, and global processes that influence sea ice growth and melt, but it is not clear what mechanisms best explain the observed variability and the slight increase in overall Antarctic sea ice extent. Many workshop discussions emphasized the distinct regional variability of Antarctic sea ice patterns. For example, most of the increase in total sea ice extent has occurred in the western Ross Sea. The *drivers* of the increases in this region are not well understood.

Climate models provide an important tool for interpreting and extending understanding of Antarctic sea ice observations as well as exploring the potential mechanisms influencing the observed variability. Much of the research to date has focused on the notable discrepancy between observations and the models, which generally exhibit a decline in Antarctic sea ice over the last 30-50 years. If the models are improved to the point that they can reliably reproduce past sea ice conditions, then they could also be used to disentangle the roles of *internal variability* and *human-caused drivers* of changes in sea ice, as well as to project how they might change in the future.

Some participants said that there is little confidence in the models that are used for attribution of Antarctic sea ice variability. For example, many of the models have a poor representation of the mean state of the Southern Ocean, which is important to reproduce observed trends in Antarctic sea ice.

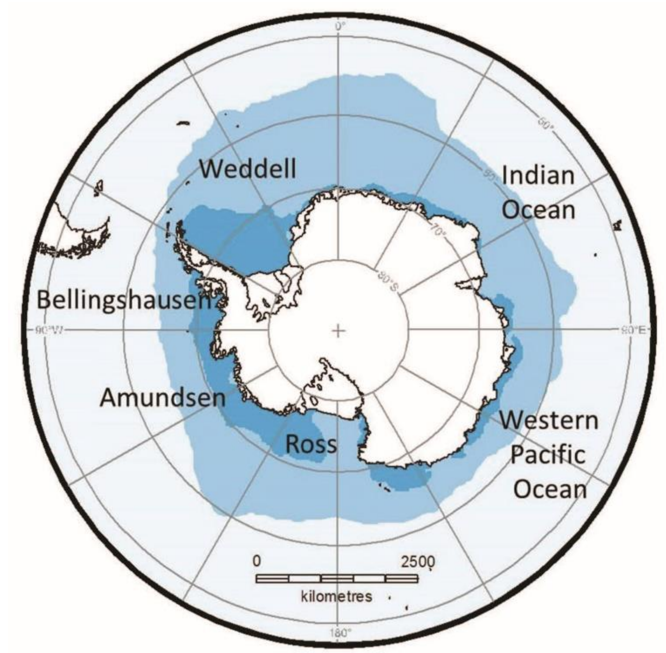


*Figure 1 – Map of Antarctica and different region sectors. Light blue indicates mean winter sea ice extent; dark blue indicates mean summer sea ice extent. From presentation by Dr. Sarah Das.*

Several methods for modeling Antarctic Sea Ice were discussed. ***One method*** is with the **free-running coupled climate model**. Such a model includes components for the atmosphere, ocean, sea ice, land, and biology. It is scientists' best attempt to replicate the climate system. The model that was used in the Intergovernmental Panel Climate Change (IPCC) Assessment Reports was a coupled climate model. Simulations using coupled climate models show the internal variability of the model's climate system (e.g., El Nino Southern Oscillation (ENSO), decadal variability) in the absence of changes in radiative forcing (difference between solar energy absorbed and heat radiated). They are long term simulations of at least 1,000 years for robust sampling. Historical simulations tend to be used for model evaluation, which is the process of evaluating climate sensitivity, internal variability, and responses to external forcing. Historical runs also provide information on the range of possible outcomes. In comparing the historical runs to observations, the observations should fit within the range of simulations. However, no single simulation needs to represent the actual observed climate, because simulations have different chronologies of decadal and multidecadal variability.

Another type of model used is the **constrained coupled climate model**. It is constrained to include the observed variability *in a certain area* and finds how that impacts other areas. Simulations from these constrained models are referred to as "Pacemaker" simulations because the observed variability in a particular area sets the "pace" for the rest of the climate system. These models are particularly good for hypothesis testing and physical and mechanistic understanding. For example, to test the influence of the tropics on the Southern Ocean, a scientist could "nudge" winds or sea surface temperatures in the tropics toward observations and allow the constrained coupled model to respond (Douville et al., 2015; Kosaka and Xie, 2013; Schneider et al., 2012a).

Antarctic sea ice can also be studied with **forced-component models.** These allow scientists to test hypotheses and gain process-level understanding. For example, to explore the influence of observed wind changes on the Southern Ocean, a scientist would prescribe the observed evolution of winds to an ocean–sea ice model. However, the models would not provide information on the origin of the wind changes (Bintaja et al., 2013; Sen Gupta and England, 2006; Zhang, 2014).

Dr. Xiaojun Yuan, Lamont-Doherty Earth Observatory, discussed a **statistical forecast model** that is capable of capturing the Antarctic sea ice response to ENSO forcing. This model depicted large inter-annual variability in sea ice concentrations in the Western Hemisphere. Sea ice in the region is quite responsive to atmospheric forcing, and he showed that sea ice anomalies are predictable with a simple statistical model.

The main conclusion of the Workshop was that models that project climate conditions decades and longer into the future seem to indicate that the Antarctic sea ice *will eventually* respond to global warming and decline. Observations from late 2016 and early 2017 indeed show decreases in Antarctic sea ice extent. Nevertheless, *many participants said a better understanding of the mechanisms is critical to making **confident** statements about the future of Antarctic sea ice.*

**Reference:**

*Antarctic Sea Ice Variability in the Southern Ocean – Climate System*. Proceedings of a Workshop. Alison Macalady and Katie Thomas, Rapporteurs, Polar Research Board, The National Academies Press, 2017.

## Are Fish From the Chesapeake Bay Safe To Eat?

*By Sally Hornor*

We know that fish are an important part of a healthy diet but we also know that the tributaries to the Chesapeake Bay are impaired with respect to toxic pollutants. Whether you fish for recreation or if you find your fish dinner at the store or at a local restaurant, you might be wondering if local fish are safe to eat. What are the contaminants of concern and what do we know about their presence in our fish and shellfish?

The Maryland Dept. of the Environment (MDE) has an extensive program in place to test for contaminants in our local fish just as the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) have a long-standing program to determine the safety of our food supply. The websites from these agencies are an excellent source of information and are heavily tapped for this article. According to the EPA, Maryland had 80 statewide coastal fish consumption advisories in 2011 for chain pickerel, large and small mouth bass, spotted seatrout, yellow perch, bluefish, striped bass and bluegill. For finfish, the primary contaminants are the heavy metal mercury, polychlorinated biphenyls (PCPs) and pesticides. For shellfish, the primary concern is microbial. The FDA is mainly concerned with mercury, and their guidelines are based on limiting consumption of mercury for pregnant women and children. According to the EPA, the extent and severity of mercury contamination is widespread throughout the watershed while metals like aluminum, chromium, or iron are more localized. Polychlorinated Chlorinated Biphenyls (PCBs) and pesticides as well as heavy metals and microbial contaminants are addressed by the MDE.

**Mercury:** About half of the mercury in our waterways is derived from coal combustion and ends up in our water through atmospheric deposition. The other half is either naturally occurring or from the combustion of municipal waste or other industrial processes. Once it sinks to the sediments, bacteria in the bottom mud convert elemental mercury to methylmercury, which is volatile and rises into the water column where it is taken up by phytoplankton and then concentrated over time through the food chain. As a result, the top predators shark, sword and tuna tend to have the highest concentrations.

Age of fish is also significant as older predators tend to have higher concentrations of metals. An article in Rodale Organic Life (2010) summarizes research published in the Journal Biological Letters where scientists collected tuna at 54 sushi restaurants and 15 grocery stores in New York, New Jersey and Colorado. They found the highest mercury concentrations in sushi grade tuna which are larger and contain more fat. But, most tuna in grocery stores is from young yellowfin tuna and has the lowest levels. For Chesapeake Bay fish, the principles of looking for younger and less fatty fish apply.

Mercury is particularly damaging to fetuses and young children as the developing human brain is exquisitely sensitive to methylmercury. This is why guidelines are set for consumption of tuna for pregnant women, women who may become pregnant and children up to the age of 7. The National Wildlife Organization has reported that one-sixth of all women of child-bearing age in the U.S. have mercury levels in their blood that exceed EPA guidelines. The EPA and the FDA have prepared guidelines for fish consumption geared toward women who are pregnant or may become pregnant, breastfeeding mothers and parents of young children (www.fda.gov/fishadvice and www.epa.gov/fishadvice). High levels of mercury will impact adults, but such levels are apparently not found in fish.

**PCBS**: PCBs were widely used up until 1977 as flame retardants in electrical equipment before we knew how toxic and persistent they are in the environment. These manmade chlorinated compounds are very tough for bacteria to degrade and therefore they tend to persist in our waterways to this day. These fat-soluble compounds are concentrated up the food chain so the top predators in the Chesapeake, rockfish (striped bass) and bluefish, tend to have the highest concentrations. PCBs are stored in skin and fat. Also, the “mustard” in crabs tends to have higher concentrations of PCBs than crab meat.

PCBs are endocrine disrupters and cause a broad range of biological impacts, ranging from damage to DNA, developmental issues and reproductive problems. According to the national Center for Disease Control, babies born to women who ate PCB-contaminated fish have been found to have weaker reflexes, less motor maturity and a more pronounced startle response. At the age of four, they still showed low weight and impaired responsiveness and memory. At age 11, they had lower than average IQs. Similarly, reduced memory and attention were seen in a study of Canadian adults who had eaten PCB-contaminated fish.

There are two pieces of good news, however: PCB levels in rockfish in the Bay have decreased between 2005 and 2010, according to MDE, and we can remove most of the PCBs in rockfish and bluefish by careful preparation. The MDE website (mde.gov) provides information regarding which fish are safe to eat as well as some excellent tips and a video on how to prepare fish to minimize these contaminants. The tips address ways to remove fat from the fish by careful filleting and by removing skin (see figure). Also, they say that bluefish and rockfish should not be breaded and fried as the PCBs tend to remain in the fat;

grilling and broiling are preferred. This can be found at https://www.youtube.com/watch?v=M08ABlPjebg. It can also be found on the MDE Fish Advisory website http://mde.maryland.gov/programs/Marylander/fishandshellfish/Pages/fishconsumptionadvisory.aspx.


**Other organic compounds: PAHs**, or polycyclic aromatic hydrocarbons, form when gas, coal and oil are burned. These organic compounds are found in our more industrially-polluted tributaries. They have been associated with liver tumors in bottom-feeding fish such as the brown bullhead catfish.

**Pesticides:** While agriculture accounts for about 75 percent of all pesticide use, 85 percent of U.S. households store at least one pesticide at home, according to MDE. In Maryland the pesticide chlordane appears to be the most prevalent contaminant in fish. Even low levels of chlordane can cause chronic liver damage and lead to liver cancer. As discussed in an earlier article (CEPA Newsletter Spring 2016), pharmaceuticals and personal care products are an emerging concern in the region. These contaminants can appear in our landfills and our wastewater, and have been linked to behavior changes and reproductive disruptions in fish and other species.

**Fish consumption guidelines vary with the source of the fish:** Fish that spend most of their life in the ocean are of concern primarily due to mercury but fish that live in our coastal waters may have a range of contaminants. The EPA has identified three "regions of concern" -- Baltimore Harbor, the Anacostia River, and the Elizabeth River. The MDE website posts a nine-page table listing number of servings of fish that can safely be eaten, depending on the river in which they are caught (Maryland_Fish_Advisories_2014_March17). Some of the recommendations, based on the most recent data, (2014) are:

* **Brown bullhead** from the Magothy River, can be eaten six times a month whereas the same fish from the Chester River can be safely eaten eight times a month but when it's from Baltimore Harbor, only once every two months.

* **Smaller rockfish** (less than 28") can be eaten three times a month but larger rockfish from anywhere in the Bay watershed should not be eaten more than once per month.

* **Smaller bluefish** from the Bay watershed (less than 15") can be eaten twice per month but there is no safe level for any bluefish consumption for larger bluefish (MDE was not able to catch enough larger bluefish to arrive at a safe limit).

**Microbial contaminants:** Since they are filter-feeders, shellfish may concentrate pathogenic viruses or bacteria as they feed. MDE monitors the fecal coliform count in areas in Maryland where shellfish are harvested commercially. These bacteria are associated with fecal waste of warm-blooded animals and thus act as indicators of contamination due to wastewater treatment plants, failing septic systems, illegal discharge or stormwater runoff. This summer, shellfish harvesting in parts of the Rhode River was closed due to high coliform counts. In addition to gastrointestinal illnesses, consumption of contaminated shellfish may also lead to hepatitis A which is associated with liver damage. All of these illnesses can be avoided by cooking shellfish, but raw oysters are popular in Maryland requiring that water quality be closely monitored. Since stormwater can be a major source of fecal contamination, oyster beds are conditionally closed for three days to harvest by MDE if more than 1" of rain falls within 24 hours. There is no restriction on crab harvest due to possible water contamination since crabs are not filter feeders.

**So, are local fish safe to eat?** In conclusion, fish and shellfish are an important part of a healthy diet. Nutritionists often recommend eating fish twice a week. They are a good source of lean protein and beneficial fatty acids. Regarding chemical contamination of local fish, the bottom line for most of us is that most fish caught locally and prepared properly are safe to eat in moderation. Caveats are in place for pregnant women and small children with respect to swordfish and tuna due to mercury levels, and large bluefish from the Bay apparently are not safe for any of us to eat. Fish caught in highly contaminated waters are suspect for PCBs and other organic pollutants and should be eaten infrequently.

## ALLIANCE FOR LIVABLE COMMUNITIES (ALC) - UPDATE

*By Mike Lofton*

At the urging of concerned citizens, the update of our General Development Plan (GDP) is underway. According to the County website, "The GDP is Anne Arundel County's comprehensive plan to **guide land use in the County, preserve its assets** and **conserve its resources**. It is prepared in compliance with State requirements and guidelines. Adopted by the County Council, the GDP establishes policies and recommendations to guide land use decisions over a **20-year planning timeframe**. All master plans and development regulations adopted by the County must be **consistent with the goals, policies and recommendations of the GDP."**

This plan will guide how and where the county grows, or doesn't grow! Decisions about zoning and the extension of public water and sewer will be based on this plan, called "Plan 2040".

The county has scheduled eight "listening sessions." These sessions are a great opportunity to speak out for improved transportation, better protections for our environment, and growth that doesn't diminish our quality of life. Your attendance at one or all of these sessions allows you to have direct input. The listening sessions will be from 6:00 PM to 8:00 PM:

| | |
|---|---|
| October 17: | Broadneck High School* |
| November 30: | Old Mill High School* |
| December 11: | Arundel High School* |
| January 11: | Annapolis High School* |
| January 29: | Northeast High School* |
| February 8: | Southern High School* |
| February 22: | Brooklyn Park Middle School* |

**dates and locations subject to change*

Participating in the process of developing Plan 2040 is one of the most important things you can do for your community. The Anne Arundel ALC encourages you to come out and be heard!

To learn more about the new plan, visit
www.aacounty.org/Plan2040
To learn more about the Alliance for Livable Communities, visit https://www.annearundel-livable.org/

**PROFILE OF A TRUSTEE**
**Jeffrey Short MD**

CEPA is happy to welcome Jeff to our Board of Trustees. He has been selected by the board to temporarily fill a vacancy and will be voted on by the membership in the next election.

Jeff is a physician at Fort Meade, MD. He grew up near Poughkeepsie, NY and graduated summa cum laude from Hamilton College in upstate New York in 1981. He went to medical school in Buffalo, NY after which he was commissioned in the US Army. He received a Masters of Public Health in Health Policy and Management from Harvard and is board certified in Emergency Medicine and Aerospace Medicine. He is a certified scuba diver and is trained in hyperbaric medicine.

Jeff spent 30 years active duty in the US Army retiring as a Colonel in 2015. He served as an aviation clinic commander, emergency department chief, chief medical officer (CMO) of a hospital, and Combat Support Hospital commander deployed to the combat zone. He has served as the Command Surgeon for three major commands advising top level commanders on health policy and medical issues. He has lived all over the country including Alaska and Hawaii. He spent time at McMurdo Station and South Pole Station in Antarctica. He has multiple combat tours, an Air Medal and two Bronze Stars.

Jeff has contributed to several academic papers and book chapters and is an accomplished instructor and speaker. He continues to teach at the Uniformed Services School of Health Sciences in Bethesda, Maryland. He has spent the last 12 years working part time in a remote hospital emergency room in Bethel, Alaska that serves the Yupik Eskimos.

An avid sailor, Jeff races on the Bay in his 34 foot catamaran. He has held positions in the Chesapeake Multihull Association including treasurer and currently serves as Commodore. He is active in the Annapolis Sail and Power Squadron (ASPS) where he has served on the budget committee, the Executive Committee, and as Executive Officer. He is currently the Commander of ASPS.

His son is a JAG officer in the Navy stationed in Norfolk. He has one daughter currently attending UNC Charlotte and another daughter who started her own business as a wedding photographer after graduating from Towson University. He lived on Fort Meade for 12 years and now lives in Severn, MD with his wife Lorrie.

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