# \*\*\*SO2 Screw\*\*\*

## ---AFF---

### CO2 Outweighs

#### Future CO2 and other GHG emissions will overwhelm SO2’s cooling capability

ClimateSight, 5/16 – ClimateSight (“ Cumulative Emissions and Climate Models,” 5/16/12, <http://climatesight.org/2012/05/16/cumulative-emissions-and-climate-models/>, //JPL)

Finding that slope is a little tricky, though. **Best estimates, using models as well as observations**, generally **fall between 1.5°C and 2°C for** every trillion tonnes of **carbon** emitted (Matthews et al, 2009; Allen et al, 2009; Zickfeld et al, 2009). Keep in mind that **we’ve already emitted about 0.6 trillion tonnes of carbon** (University of Oxford). Following a theme commonly seen in climate research, **the uncertainty is larger on the high end of these slope estimates than on the low end**. So if the real slope is actually lower than our best estimate, it’s probably only a little bit lower; **if it’s actually higher than our best estimate, it could be much higher, and the problem could be much worse than we thought**. Also, **this approach ignores other human-caused influences on global temperature, most prominently sulfate aerosols (which cause cooling) and greenhouse gases other than carbon dioxide (which cause warming**). **Right now, these two influences basically cancel**, which is convenient for scientists because it means we can ignore both of them. Typically, we assume that they will continue to cancel far into the future, which might not be the case – **there’s a good chance that developing countries like China and India will reduce their emissions of sulfate aerosols, allowing the non-CO2 greenhouse gases to dominate and cause warming**. If this happened, we couldn’t even lump the extra greenhouse gases into the allowable CO2 emissions, because the warming they cause does depend on the exact pathway. For example, methane has such a short atmospheric lifetime that “cumulative methane emissions” is a useless measurement, and certainly isn’t directly proportional to temperature change.

### Timeframe

#### SO2 doesn’t just immediately fall out; that process also takes years, their timeframe is just as long

Gosselin, 5/4 - Associate Degree in Civil Engineering at Vermont Technical College and a Bachelor of Science in Mechanical Engineering at the University of Arizona in Tucson (P. Gosselin, “ Russian Sulfur Dioxide May Be The Cause Of Arctic Warming,” NoTricksZone, <http://notrickszone.com/2012/05/04/russian-sulfur-dioxide-may-be-the-cause-of-arctic-warming/>, //JPL)

**Sulfur dioxide, SO2, is not a greenhouse gas. But it should not be ignored when discussing climate**. We know that the SO2 injected into the stratosphere by large volcanoes such as Agung, El Chichon, and Pinatubo, can cause cooling for a period of years. This is because of the reflective haze created by SO2 **combining with water vapor to create sulphuric acid aerosol that then takes two or three years to fall down to altitudes where they find enough water vapor to grow, form clouds, and rain out**.

### Warming Thumper

#### Even if they are right that SO2 has a direct cooling effect, it causes chemical reactions that make all other greenhouse gases cause more warming; there’s a tipping point

Ward, 9 - U. S. Geological Survey from 1971 to 1998, playing a lead role in development of the United States National Earthquake Hazards Reduction Program, MA and Ph.D from Columbia University, former Chief in Branch of Seismology at USGS (“ Sulfur Dioxide Initiates Global Climate Change in Four Ways: Notes for Science Writers,” 2/8/9, <http://www.tetontectonics.org/Climate/Notes%20For%20Science%20Writers.pdf>, //JPL)

The IPCC emphasizes that **methane is a greenhouse gas that absorbs much more energy than carbon dioxide**. They explain the increasing amounts of methane as resulting from increases in methane sources on earth such as changes in the number of cows, peat bogs or rice paddies. **The increase in methane can be explained in another way. The hydroxyl radical reacts with sulfur dioxide in a fraction of a second**. **It reacts more slowly with methane, oxides of nitrogen and other greenhouse gases. Thus sulfur dioxide “steals” the oxidants that become available. Too much sulfur dioxide causes methane and other greenhouse gases to accumulate**. **Low concentrations of sulfur dioxide leave oxidants available to react with methane and other greenhouse gases, lowering world temperatures**. This is another very important concept in understanding global warming: **Large quantities of sulfur dioxide reduce the oxidizing capacity of the atmosphere**, thereby **changing the atmosphere’s ability to cleanse itself and** thereby **increasing concentrations of methane**. To belabor the point: The IPCC is primarily concerned with emissions. I am primarily concerned with the atmosphere’s ability to remove these emissions through oxidation. Both affect atmospheric concentrations, but I argue that **oxidation is far more important**. Sulfur dioxide opens and closes two types of venetian blinds. Sulfur dioxide and water emitted during a large volcanic eruption forms an aerosol in the lower stratosphere that closes those venetian blinds that govern incoming solar radiation, reflecting sunlight and thereby cooling the earth. **Sulfur dioxide in the troposphere is largely oxidized. Too much sulfur dioxide, especially in the troposphere, reduces the oxidizing capacity of the atmosphere**, closing a different set of venetian blinds that govern outgoing longwave radiation and thereby warming the earth. What closes these blinds is the rapid buildup of greenhouse gases, including sulfur dioxide, in the troposphere. How much sulfur dioxide is too much? These are details that will need to be worked out by atmospheric chemists, but my observations demonstrate that warming becomes a problem when there is at least one large, Pinatubo-sized volcanic eruption every two years.

### Black Carbon Thumper

#### Black carbon negates the cooling effects aerosols normally would have

Scientific American, 1, 2/8/’1 (<http://www.sciam.com/print_version.cfm?articleID=00031A3A-C01F-1C5A-B882809EC588ED9F>)

Though it pours ominously out of chimneys, forest fires and the exhaust pipes of diesel-run vehicles (*right*), soot has received little attention from scientists studying global warming. Results published today in the journal *Nature,* however, suggest that soot, 90 percent of which comes from burning fossil fuels and biomass, may be a leading cause of rising world temperatures. "Soot—or black carbon—may be responsible for 15 to 30 percent of global warming," says Stanford University researcher Mark Z. Jacobson, the author of the report. "Yet it's not even considered in any of the discussions about controlling climate change." The conventional model of global heat balance holds that greenhouse gases warm the earth by trapping infrared radiation, while aerosol particles in the atmosphere reflect sunlight back into space, reducing the amount of heat the planet absorbs. The aerosols, in this view, cool the earth in the same way that light-colored clothing keeps you cooler on a hot day than dark-colored clothing. But according to the new findings, soot in these atmospheric aerosols may cancel out the sulfate that makes them such effective cooling agents by darkening the aerosols so that they soak up more radiation. Jacobson notes that of the few previous studies that considered the impact of soot on global warming, most assumed that soot doesn't mix with other particles in the atmosphere. His own research, based on computer simulations, suggests quite the opposite, indicating that within five days of entering the atmosphere, particles of pure soot will probably end up in mixtures. Simulating how millions of tons of mixed soot would affect climate yielded dramatic results. "These black carbon mixtures turn out to be one of the most important components of global warming," Jacobson observes, "perhaps second only to carbon dioxide." Thus, reducing soot emissions could be one effective way to counter global warming, he says.

#### Models prove reducing soot key to stop warming; black carbon causes their models to make flawed assumptions about benefits of SO2

Skirble, 11 – reporter for Voice of America news (Rosanne, “ Study: Reducing Soot is Fastest Way to Slow Climate Change,” Voice of America News, <http://www.voanews.com/content/study-reducing-soot-is-fastest-way-to-slow-climate-change-129070528/169690.html>, //JPL)

A **new study finds that reducing carbon-rich soot emissions could be the fastest and most economical way to slow climate change** and protect human health. **Those dust-like particles released** in the exhaust of diesel-powered vehicles and wood fires **rank second only to carbon dioxide as a major cause of global warming**. **Stanford University professor Mark Jacobson developed the first computer models to measure the presence of soot in the atmosphere**. He calculates that **soot accounts for between 15 and 20 percent of global warming**. His study, presented this week at the American Chemical Society meeting in Colorado, describes how **black carbon - the main component in soot - heats up clouds when it mingles with the rain drops suspended within them**. “And it turned out that **there is more heating when the black carbon was inside the drop than between the drops and there was more heating when the black carbon was between the drop than outside of the cloud**. So the bottom line was **you get this enhancement of the heating of the cloud by the black carbon presence in the cloud drops**.” Jacobson says **climate models that ignore this cloud absorption phenomenon underestimate the effects of black carbon** in the atmosphere. His research found that **airborne soot quickly burns off cloud cover**. Soot reduction could slow the melting of the arctic which is expected to be ice free within 30 years if no action is taken. “**If you look at satellite images over really polluted areas such as in China and India you can actually see an absence of clouds**.” While carbon dioxide can remain in the atmosphere for 40 or 50 years, carbon soot stays around only for a week or 10 days before settling out, and has no continuing warming effect. “Soot is a solar absorber, whereas carbon dioxide is primarily a heat absorber. Now, **per unit mass, black carbon is about a million times more powerful in warming the air than is carbon dioxide**. But because soot, black carbon in soot, are so powerful and warming and because they are very short-lived, that is actually important for control strategies for global warming.” Case in point: The Arctic is warming faster than anywhere on the planet. The white sea ice, which normally reflects sunlight and heat back into space, is giving way to darker areas of open water, which absorbs heat faster, and so accelerates the warming. **The Arctic could be ice free within 30 years, according to recent studies. Jacobson says reducing the amount of soot in the atmosphere can reverse this trend**. “And you can slow down the loss of the Arctic ice. And so it may be the only way to prevent or slow down the elimination of the Arctic. And that has implications, of course, not only for climate feedbacks, but also for wildlife such as polar bears which rely on ice floes to survive.”

### SO2 Bad – Warming

#### SO2 causes warming- multiple feedback loops- all other studies fail because they don’t assume other particles

Science Daily, 10 (Best Hope for Saving Arctic Sea Ice Is Cutting Soot Emissions, Say Researchers, July 30, 2010, <http://www.sciencedaily.com/releases/2010/07/100728092617.htm>)

**The quickest, best way to slow the rapid melting of Arctic sea ice is to reduce soot emissions** from the burning of fossil fuel, wood and dung, according to a new study by Stanford researcher Mark Z. Jacobson. His analysis shows that soot is second only to carbon dioxide in contributing to global warming. But, he said, climate models to date have mischaracterized the effects of soot in the atmosphere. Because of that, soot's contribution to global warming has been ignored in national and international global warming policy legislation, he said. "**Controlling soot may be the only method of significantly slowing Arctic warming within the next two decades,"** said Jacobson, director of Stanford's Atmosphere/Energy Program. "We have to start taking its effects into account in planning our mitigation efforts and the sooner we start making changes, the better." To reach his conclusions, Jacobson used an intricate computer model of global climate, air pollution and weather that he developed over the last 20 years that included atmospheric processes not incorporated in previous models. He examined the effects of soot -- black and brown particles that absorb solar radiation -- from two types of sources. He analyzed the impacts of soot from fossil fuels -- diesel, coal, gasoline, jet fuel -- and from solid biofuels, such as wood, manure, dung, and other solid biomass used for home heating and cooking in many locations. He also focused in detail on the effects of soot on heating clouds, snow and ice. **What he found was that the combination of both types of soot is the second-leading cause of global warming** after carbon dioxide. That ranks the effects of soot ahead of methane, an important greenhouse gas. He also found that soot emissions kill more than 1.5 million people prematurely worldwide each year, and afflicts millions more with respiratory illness, cardiovascular disease and asthma, mostly in the developing world where biofuels are used for home heating and cooking. Jacobson's study will be published in *Journal of Geophysical Research (Atmospheres)*. **Reducing soot could have immediate impact It is the magnitude of soot's contribution, combined with the fact that it lingers in the atmosphere for only a few weeks before being washed out, that leads to the conclusion that a reduction in soot output would start slowing the pace of global warming almost immediately**. Greenhouse gases, in contrast, typically persist in the atmosphere for decades -- some up to a century or more -- creating a considerable time lag between when emissions are cut and when the results become apparent. Mark Jacobson found that eliminating soot produced by the burning of fossil fuel and solid biofuel could reduce warming above parts of the Arctic Circle in the next 15 years by up to 1.7 degrees Celsius. Jacobson found that eliminating soot produced by the burning of fossil fuel and solid biofuel could reduce warming above parts of the Arctic Circle in the next 15 years by up to 1.7 degrees Celsius. For perspective, net warming in the Arctic has been at least 2.5 degrees Celsius during the last century and is expected to warm significantly more in the future if nothing is done. The most immediate, effective and low-cost way to reduce soot emissions is to put particle traps on vehicles, diesel trucks, buses, and construction equipment. Particle traps filter out soot particles from exhaust fumes. Soot could be further reduced by converting vehicles to run on clean, renewable electric power. Jacobson found that although fossil fuel soot contributed more to global warming, biofuel-derived soot caused about eight times the number of deaths as fossil fuel soot. Providing electricity to rural developing areas, thereby reducing usage of solid biofuels for home heating and cooking, would have major health benefits, he said. **Soot from fossil fuels contains more black carbon than soot produced by burning biofuels, which is why there is a difference in impact. Black carbon is highly efficient at absorbing solar radiation in the atmosphere**, just like a black shirt on a sunny day. Black carbon converts sunlight to heat and radiates it back to the air around it. This is different from greenhouse gases, which primarily trap heat that rises from the Earth's surface. **Black carbon can also absorb light reflecting from the surface, which helps make it such a potent warming agent. First model of its type Jacobson's climate model is the first global model to use mathematical equations to** describe the physical and chemical interactions of soot particles in cloud droplets in the atmosphere. This allowed him to include details such as light bouncing around inside clouds and within cloud drops, which he said are critical for understanding the full effect of black carbon on heating the atmosphere. "**The key to modeling the climate effects of soot is to account for all of its effects on clouds, sea ice, snow and atmospheric heating**," Jacobson said. Because of the complexity of the processes, he said it is not a surprise that **previous models have not correctly treated the physical interactions required to simulate cloud, snow, and atmospheric heating by soot. "But without treating these processes, no model can give the correct answer with respect to soot's effects**," he said. Jacobson argues that leaving out this scale of detail in other models has led many scientists and policy makers to undervalue the role of black carbon as a warming agent. The strong global heating due to soot that Jacobson found is supported by recent findings of Veerabhadran Ramanathan, a professor of climate and atmospheric science at the Scripps Institute of Oceanography, who measures and models the climate effects of soot. "Jacobson's study is the first time that a model has looked at the various ways black carbon can impact climate in a quantitative way," said Ramanathan, who was not involved in the study. **Black carbon has an especially potent warming effect over the Arctic**. When black carbon is present in the air over snow or ice, sunlight can hit the black carbon on its way towards Earth, and also **hit it as light reflects off the ice and heads back towards space**. "It's a double-whammy over the ice surface in terms of heating the air," Jacobson said. **Black carbon also lands on the snow, darkening the surface and enhancing melting. "There is a big concern that if the Arctic melts, it will be a tipping point for the Earth's climate** because the reflective sea ice will be replaced by a much darker, heat absorbing, ocean below," said Jacobson. "**Once the sea ice is gone, it is really hard to regenerate because there is not an efficient mechanism to cool the ocean down in the short term."** Jacobson's work was supported by grants from the U.S. Environmental Protection Agency, NASA, the NASA high-end computing program and the National Science Foundation.

#### Thousands of years of modeling prove SO2 has a net heating effect; also humans aren’t the main cause

Ward, 9 - U. S. Geological Survey from 1971 to 1998, playing a lead role in development of the United States National Earthquake Hazards Reduction Program, MA and Ph.D from Columbia University, former Chief in Branch of Seismology at USGS (“ Sulfur Dioxide Initiates Global Climate Change in Four Ways: Notes for Science Writers,” 2/8/9, <http://www.tetontectonics.org/Climate/Notes%20For%20Science%20Writers.pdf>, //JPL)

Figure 2 shows that the concentration of volcanic sulfate in individual layers of ice in the Greenland ice sheet is highest during the times when global warming was greatest (W) and was lowest when re-glaciation was greatest (C). **Sulfate comes primarily from volcanoes, sea salt, and blown dust**. Sea salt also contains sodium and blown dust contains calcium. Thus the amounts of sulfate from sea salt and dust can be estimated by the amounts of sodium and calcium and then subtracted from the total sulfate to determine the amount of “volcanic” sulfate. In analyzing the data from Greenland shown in Figure 2, Paul Mayewski (Journal of Geophysical Research, 1997, volume 102, page 26345) used a mathematic method called empirical orthogonal function that looks at the concentrations of all of the chemicals measured and groups them in the most chemically sensible ways. Thus the amounts of “volcanic” sulfate shown in Figure 2 are a reasonable proxy for the amount of volcanic activity (except in the 20 th century when sulfur emissions by man became important). It turns out that **one large volcanic eruption typically causes a deposit of approximately 50 parts per billion sulfate** in Greenland. This value changes with the size of the eruption, the latitude of the volcano, the distance from Greenland, and the chemistry of its magma, but 50 ppb is a reasonable approximation. **Sulfate comes from oxidizing sulfur dioxide. The association of sulfate (sulfur dioxide**) in Figure 2 **with global warming is very clear and unambiguous. A more detailed look at all the data shows that the amount of warming is** typically **proportional to** the amount of **sulfate, especially when the warming lasts for several hundred years**. The tall peak in sulfate at 13,600 years is accompanied by warming, but not as great warming as the peaks surrounded by other peaks. The duration of high sulfate is more important than the amount. One could develop statistics to quantify the relationship, but statistics of small numbers are unreliable and the correlation is extremely clear to the eye. I show in Figures 7, 8, and 9 in the main paper that each known time of significant warming going back 46,000 years is contemporaneous, within the errors of the data, with each peak in major volcanic activity and visa versa. **The sulfate record in the GISP2 hole goes back to 100,000 years before present**. I stopped at 46,000 because the signal levels were getting too small to be reliable. **There is very low noise in this relationship** because more than 70% of the ice layers contain no volcanic sulfate. One can argue about the fine details of the correlation, but **the main correlation between volcanism and global warming cannot be denied** other than to argue that it might just be fortuitous. The clear correlation of low volcanism and re-glaciation argues against chance.

### SO2 Bad – Warming / Acid Rain

#### SO2 causes more warming specifically in the Arctic which is key – also causes acid rain

Gosselin, 5/4 - Associate Degree in Civil Engineering at Vermont Technical College and a Bachelor of Science in Mechanical Engineering at the University of Arizona in Tucson (P. Gosselin, “ Russian Sulfur Dioxide May Be The Cause Of Arctic Warming,” NoTricksZone, <http://notrickszone.com/2012/05/04/russian-sulfur-dioxide-may-be-the-cause-of-arctic-warming/>, //JPL)

We know that **SO2 from industry and fossil fueled power plants form smogs and low clouds that produce acid rain down wind from the sources. We know what damage acid rain can do when the acid content is high enough to harm plant life**. But **little attention has been paid to the climate effects of the smogs themselves**. We know that **low clouds and fogs keep surface temperatures from falling at night**, as well as keeping surface temperatures from rising during daylight. We know that **in the polar regions in winter it is night all the time. Now put those things together. In the Arctic, in winter, smogs and low clouds caused by SO2 will trap heat below them 24 hours a day**, and in the spring will prevent sunlight from reaching and warming the surface. On the Arctic Ocean, this will delay both freezing in the winter and melting in the spring. We can see clearly that the freeze-up in the Arctic has been delayed in recent years compared to the 1979 to 2006 average. Because the freeze-up is delayed, there is less ice to thaw in the spring, so that delay is less obvious, except that the ice minimum is also delayed compared to the average. Now we get to why? First, we look at two temperature anomaly maps of the Arctic. Norilsk is the location of the world’s largest nickel mine. They also recover copper, cobalt, platinum, and palladium. Nearby, coal is mined to support the power needs of the city (130,000 population), the mine, and the smelter operations. SO2 emissions are about one million metric tons per year. This one location is responsible for 1% of all the SO2 emissions in the world, 10% of all of Europe’s emissions. CNN reports that there is not a single living tree within 48 kilometers (30 miles) of the nickel smelter. **2,832 square kilometers** (1093 square miles) **of forest have been killed, and another 5371 square kilometers** (2073 square miles) **have been damaged**. For a full report on the damage read this pdf document. Norilsk Mining has other smelters on the Kola Peninsula very close to the Norwegian border. They also emit large amounts of SO2. Both locations are well above the Arctic Circle. All **these emissions are within a very sensitive part of the Earth: the Arctic**. During the winter, the winds in the Arctic are variable, depending on the position of the Arctic front. The winds alternate between blowing to and from the land, moving any pollution over the Arctic Ocean or inland. In Figure 2b, in March, the pollution from Norilsk was moving over the ocean much of the time. You can see the ebb and flow of the winds as they moved the sea ice in an animation of the last year here (from NRL). **Normally, SO2 is not a greenhouse gas, but it is in the** dark of winter in the **Arctic**. **In combination with water vapor**, which is a greenhouse gas, **it produces smog and low clouds that reflect heat back to the surface** when it is dark, and upward into space when the sun shines. **This distorts the melting and freezing patterns resulting in less ice in the Arctic Ocean**. Yes, the reduction in ice in the Arctic is anthropogenic, with a Russian accent. One thing people don’t know is that the platinum/palladium used in in automotive catalytic converters comes from Norilsk. We are simply moving the pollution from a distributed source, automobiles, to a concentrated source in Siberia. We are all responsible for Arctic warming.

### SO2 Bad – Acid Rain

#### SO2 causes acid rain – that acidifies the world’s water supplies

Seitz & Hite, 12 – John Seitz, professor at Wofford College, former official at the State Department in the office of Aid for International Development, former member of the CIA, yeah, that CIA; Kristen Hite, B.A. and B.S., Wofford College (2000) M.S. in environmental management, University of San Francisco de Quito, Ecuador J.D., Georgetown University Law School, Washington, D.C., official at Center for International Environmental Law, Washington, D.C. (Global Issues: An Introduction, Wiley-Blackwell Publishing, February, 2012, //JPL)

**When fossil fuels are burned, sulfur dioxide and oxides of nitrogen are released into the air. As these gases react with moisture and oxygen in the atmosphere in the presence of sunlight, the sulfur dioxide becomes sulfuric acid (the same substance used in car batteries) and the oxides of nitrogen become nitric acid. These acids then return to earth in rain, snow, hail, or fog**. When they do, **they** can **kill fish in lakes and streams, dissolve limestone statues and gravestones, corrde metal, weaken trees, making them more susceptible to insects and drought, and reduce the growth of** some **crops**. The effects of acid rain on human health are not yet known. Some scientists fear that **acid rain could** help **dissolve toxic metals in water pipes and in the soil, releasing these metals into people’s water supplies**. In the United States, acid rain comes mainly from sulfur dioxide produced by coal-burning electricity-generating power plants in the Midwest and from the nitrogen oxides from auto and truck exhausts. **Acid rain has caused lakes in the northeastern part of the country to become so acidic that fish and other organisms are unable to live in them**.

#### Acid rain causes destruction in multiple areas of the environment; all marine life will die

Lindstrom, 11 - Professor of Political Science with Saint John's University/College of Saint Benedict since 2005, Ph.D from North Arizona University (Matthew, Encyclopedia of the U.S. Government and the Environment, 2011, //JPL)

**Acid rain has been a fully realized ecological problem** for only a few decades. The effects of acid rain have been recorded in the eastern United States, Great Britain, Germany, and elsewhere. More recently, **acid rain is becoming a significant problem** in China, Japan, and other rapidly industrializing nations like India and Taiwan. **Scientists fear the negative effects will continue to worsen unless governments and industries work together. Acid rain can affect bodies of water by increasing the acidity until fish and marine vegetation can no longer survive**. As acidity rises, **forms of aquatic life struggle to survive**. At pH 5.5, bottom-dwelling bacterial decomposers start to disappear, leaving organic debris to collect. In such cases, **plankton, the base of the aquatic system, lack its food source, negatively affecting all marine life**. Further, if the composed leaf litter problem persists, **toxic metals such as aluminum and mercury can be released and seep into the groundwater. At pH levels of 4.5 and below, nearly all aquatic life will die**. **Acid rain also greatly affects forests and soil by washing away vital nutrients and replacing them with harmful toxins. Some of the great forests in Germany and western Europe are** believed to be **dying from acid deposition**, which is a result of a combination of wet and dry acid pollution. Scientists believe **essential nutrients for plant life are washed away by acid rain, which can also affect crop yields**. During this process, **toxic metals are transferred from the atmosphere to forests. These** deposits of lead, zinc, copper, chromium, and aluminum, among others, **retard growth of local plant life**, as well as mosses, algae, nitrogen-fixing bacteria, and fungi, all of which contribute to the health of forests.

### SO2 Bad – Ozone

#### Emitting enough SO2 to solve warming wrecks the ozone

Schmid, 11 RANDOLPH E. SCHMID [July 4, 2011](http://www.physorg.com/archive/04-07-2011/), AP Science Writer Global warming pause linked to sulfur in China http://www.physorg.com/news/2011-07-global-linked-sulfur-china.html

But **sulfur's cooling effect is only temporary, while the carbon dioxide from coal burning stays in Earth's atmosphere a long time**. Chinese coal consumption doubled between 2003 and 2007, and that caused a 26 percent increase in global coal consumption, Kaufmann said. Now, **Chinese leaders have recognized the effects of** that **pollution on their environment and their citizens' health and are installing equipment to scrub out the sulfur particles**, Kaufmann said. **Sulfur quickly drops out of the air if it is not replenished, while carbon dioxide remains for a long time, so its warming effects are beginning to be visible again**, he noted. The plateau in temperature growth disappeared in 2009 and 2010, when temperatures lurched upward. Indeed, NASA and the [National Oceanic and Atmospheric Administration](http://www.physorg.com/tags/national+oceanic+and+atmospheric+administration/), have listed 2010 as tied for the warmest year on record, while the Hadley Center of the British Meteorological Office lists it as second warmest, after 1998. Sulfur's ability to cool things down has led some to suggest using it in a geoengineering feat to cool the planet. **The idea is that injecting sulfur compounds very high into the atmosphere might help ease global warming by increasing clouds and haze that would reflect sunlight.** Some **research has concluded that's a bad idea.** **Using enough sulfur to reduce warming would wipe out the protective Arctic ozone layer and delay recovery of the Antarctic ozone hole by as much as 70 years**, according to an analysis by Simone Tilmes of the National Center for Atmospheric Research in Boulder, Colo. This is the ozone layer that is high above Earth and protects against harmful UV rays, not the ground level ozone that is a harmful pollutant. "While climate change is a major threat, more research is required before society attempts global geoengineering solutions," said Tilmes. Overall, global temperatures have been increasing for more than a century since the industrial revolution began adding gases like carbon dioxide to the air. But there have been similar plateaus, such as during the post-World War II era when industrial production boosted [sulfur](http://www.physorg.com/tags/sulfur/) emissions in several parts of the world, Kaufmann explained. Atmospheric scientists and environmentalists are concerned that continued rising temperatures could have serious impacts worldwide, ranging from drought in some areas, changes in storm patterns, spread of tropical diseases and rising sea levels.

### A2: Global Dimming Good – BioD

#### Continued global dimming will cause droughts that wipe out developing countries and cause ecological disasters

Schueneman, 10 - Associate Editor at TriplePundit.com (Thomas, “ EarthTalk: What is Global Dimming?,” Environmental News Network, 12/16/10, <http://www.enn.com/pollution/article/42125>, //JPL)

Particulate **pollution also changes the properties of clouds—so-called "brown clouds**" are more reflective and **produce less rainfall** than their more pristine counterparts. The reduction in heat reaching the Earth's surface as a result of both of these processes is what researchers have **dubbed global dimming. "At first, it sounds like an ironic savior to climate change** problems," reports Anup Shah of the website GlobalIssues.org. "**However, it is believed that global dimming caused the droughts in Ethiopia in the 1970s and 80s where millions died, because the northern hemisphere oceans were not warm enough to allow rain formation**." He adds that **global dimming is also hiding the true power of global warming: "By cleaning up global dimming-causing pollutants without tackling greenhouse gas emissions, rapid warming has been observed, and various human health and ecological disasters have resulted**, as witnessed during the European heat wave in 2003, which saw thousands of people die."

# \*\*\*Ocean Acidification\*\*\*

## ---Uniqueness/Now Key---

### Uniqueness

#### Ocean acidification is happening now and destroying coral reefs and hurting food supply globally– reducing carbon emissions is critical to solve

AP 7/9 (7/9/2012, “Extra carbon dioxide from the atmosphere has ended up in the world's oceans, increasing the acidity of the sea, scientists say. Reducing carbon emissions could help solve the problem,” http://www.csmonitor.com/Science/2012/0709/Ocean-acidity-increases-surprise-researchers)JCP

**Oceans' rising acid levels have emerged as one of the biggest threats to coral reefs,** acting as the "osteoporosis of the sea" **and threatening everything from food security to tourism to livelihoods,** the head of a U.S. scientific agency said Monday**. The speed by which the oceans' acid levels has risen caught scientists off-guard, with the problem now considered to be climate change's "equally evil twin,"** National Oceanic and Atmospheric Administration chief Jane Lubchenco told The Associated Press. "**We've got sort of the perfect storm of stressors from multiple places really hammering reefs around the world**," said Lubchenco, who was in Australia to speak at the International Coral Reef Symposium in the northeast city of Cairns, near the Great Barrier Reef. "**It's a very serious situation."** **Oceans absorb excess carbon dioxide in the atmosphere, increasing sea acidity. Scientists are worried about how that increase will affect sea life, particularly reefs, as higher acid levels make it tough for coral skeletons to form**. Lubchenco likened ocean acidification to osteoporosis — a bone-thinning disease — because researchers are concerned it will lead to the deterioration of reefs. **Scientists initially assumed that the carbon dioxide absorbed by the water would be sufficiently diluted** as the oceans mixed shallow and deeper waters. **But most of the carbon dioxide and the subsequent chemical changes are being concentrated in surface waters**, Lubchenco said. **"**And those surface waters are changing much more rapidly than initial calculations have suggested," she said. "**It's yet another reason to be very seriously concerned about the amount of carbon dioxide that is in the atmosphere now and the additional amount we continue to put out." Higher acidity levels are especially problematic for creatures such as oysters**, because acid slows the growth of their shells. Experiments have shown **other animals, such as clown fish, also suffer**. In a study that mimicked the level of acidity scientists expect by the end of the century, clown fish began swimming toward predators, instead of away from them, **because their sense of smell had been dulled.** "**We're just beginning to uncover many of the ways in which the changing chemistry of oceans affects lots of behaviors**," Lubchenco said. "**So salmon not being able to find their natal streams because their sense of smell was impaired, that's a very real possibility." The potential impact of all of this is huge**, Lubchenco said. **Coral reefs attract critical tourism dollars and protect fragile coastlines from threats such as tsunamis. Seafood is the primary source of protein for many people around the world**. Already, some oyster farmers have blamed higher acidity levels for a decrease in stocks. Some attempts to address the problem are already under way. Instruments that measure changing acid levels in the water have been installed in some areas to warn oyster growers when to stop the flow of ocean water to their hatcheries. But that is only a short-term solution, Lubchenco said**. The most critical element,** she said, **is reducing carbon emissions**. "**The carbon dioxide that we have put in the atmosphere will continue to be absorbed by oceans for decades,"** she said. "**It is going to be a long time before we can stabilize and turn around the direction of change simply because it's a big atmosphere and it's a big ocean."**

### Now is key- Feedbacks

#### Now key time-ocean sinks

Venkataramanan and smitha ‘11(Department of Economics, D.G. Vaishnav College, Chennai, India Indian Journal of Science “Causes and effects of global warming p.226-229 March 2011 http://www.indjst.org/archive/vol.4.issue.3/mar11-pages159-265.pdf KG)

Causes of global warming: **The buildup of carbon dioxide in the atmosphere, mainly from your fossil fuel emissions, is the most significant human cause of global warming.** Carbon dioxide is released every you burn something, be it a car, airplane or coal plant. **This means you must burn less fossil fuel if you want the Earth's climate to remain stable! And unfortunately, we are currently destroying some of the best known mechanisms for storing that carbon-plants. Deforestation increases the severity of global warming as well. Carbon dioxide is released from the human conversion of forests and grasslands into farmland and cities. All living plants store carbon. When those plants die and decay, carbon dioxide is released back into the atmosphere.** As forests and grasslands are cleared for your use, enormous amounts of stored carbon enter the atmosphere. An unstoppable feedback loop may happen if you let this continue. **If the activities mentioned above warm the Earth just enough, it could cause natural carbon sinks to fail. A "carbon sink" is a natural system that stores carbon over thousands of years. Such sinks include peat bogs and the arctic tundra. But if these sinks destabilize, that carbon will be released, possibly causing an unstoppable and catastrophic warming of the Earth. The oceans are no longer able to store carbon as they have in the past. The ocean is a huge carbon sink, holding about 50 times as much carbon as the atmosphere. But now scientists are realizing that the increased thermal stratification of the oceans has caused substantial reductions in levels of phytoplankton, which store CO2. Increased atmospheric carbon is also causing an acidification of the ocean**, since carbon dioxide forms carbonic acid when it reacts with water. **The tiny plants of the ocean, the very bottom of that vast watery food chain, are suffering from the effects of global warming, which means they are becoming less able to store carbon, further contributing to climate change. As carbon sinks fail, the amount of carbon in the atmosphere climbs!**

#### Ocean acidification now is unique and more likely to cause mass extinctions than any other instance in history

Parry 12 – Staff Writer for Live Science, citing a study lead by Barbel Honisch – a paleoceanographer at Columbia University (Wynne, March 2, 2012, “Oceans Turning Acidic Faster than Past 300 Million Years,” http://www.livescience.com/18786-ocean-acidification-extinction.html)JCP

**The oceans are becoming more acidic faster than they have in the past 300 million years, a period that includes four mass extinctions,** researchers have found. **Then, as is happening now, increases in carbon dioxide in the atmosphere warmed the planet and made the oceans more acidic. These changes are associated with major shifts in climate and mass extinctions. But while past increases in the atmosphere's carbon dioxide levels resulted from volcanoes and other natural causes, today that spike is due to human activities, the scientists note**. "**What we're doing today really stands out,"** lead researcher Bärbel Hönisch, a paleoceanographer at Columbia University's Lamont-Doherty Earth Observatory, said in a news release. "**We know that life during past ocean acidification events was not wiped out — new species evolved to replace those that died off. But if industrial carbon emissions continue at the current pace, we may lose organisms we care about — coral reefs, oysters, salmon." [Humans Causing 6th Mass Extinction**] **As the level of carbon dioxide in the atmosphere increases, oceans absorb that carbon dioxide, which turns into a carbon acid**. As a result the pH — a measure of acidity — drops, meaning the water has become more acidic. **This dissolves the carbonates needed by some organisms, like corals, oysters or the tiny snails salmon eat.** In their review, published Thursday (March 1) in the journal Science, Hönisch **and colleagues found the closest modern parallel about 56 millions ago in what is called the Paleocene-Eocene Thermal Maximum, when atmospheric carbon concentrations doubled, pushing up global temperatures. Extinctions in the deep sea accompanied this shift**. (The PETM occurred about 9 million years after the dinosaurs went extinct.) **But, now, the ocean is acidifying at least 10 times faster than it did 56 million years ago**, according to Hönisch. **Ocean acidification may also have occurred** when volcanoes pumped massive amounts of carbon dioxide into the air 252 million years ago, **at the end of the Permian period, and** 201 million years ago, at the end of the **Triassic period**, they found. **Both are associated with mass extinctions**. "**The current rate of (mainly fossil fuel) carbon dioxide release stands out as capable of driving a combination and magnitude of ocean geochemical changes potentially unparalleled in at least the last 300 million years of Earth history, raising the possibility that we are entering an unknown territory of marine ecosystem change,**" the researchers conclude in their paper.

## ---Internal Links---

### Generic Internals

#### CO2 leads to ocean acidification- more CO2 also makes the ocean less resistant to changes in acidity

NRC 10 (The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy’s purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. RalpOcean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean”, pdf- download at http://www.nap.edu/catalog.php?record\_id=12904)//JM

The exchange of CO2 at the air-water interface is relatively fast, taking place on a time scale of months to a year so that, on average, the concentration of CO2 in surface seawater remains approximately at equilibrium with that of the atmosphere. As the concentration of atmospheric CO2 gas increases year after year, some of it dissolves into the ocean such that about a third of the total CO2 added to the atmosphere from anthropogenic sources --including fossil fuel emissions, cement production and deforestation-- over the past 150 years is now dissolved in the oceans (Sabine et al., 2004; Khatiwala, et al., 2009). The increase in dissolved CO2 concentration decreases the pH and shifts the equilibrium of inorganic carbon species in seawater, resulting in an increase in CO2 and HCO3 - concentrations and a decrease in CO3 2concentration (Figure 2.4). For example, under present conditions in the mid North Pacific, for every 100 molecules of CO2 dissolved from the atmosphere, about 7 remain as CO2, 15 react with B(OH)4 -, and 78 react with CO3 2-, resulting in an increase of HCO3 - by 171 molecules. The buffering capacity of seawater—the ability to resist changes in acid-base chemistry upon addition of an acid such as CO2—depends on the concentration of bases, principally CO3 2- and B(OH)4 -, to neutralize the acid (Figures 2.1 and 2.4). Upon acidification of the oceans, the buffering capacity of seawater will decrease along with pH. Also, ocean water masses that are presently already high in CO2 for any reason are less buffered against further increases in CO2 than those with lower CO2 (Egleston et al., 2010).

#### Increase in CO2 changes the chemical balance of the ocean

Doney et al. ’09 **(**Scott C. Doney, Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution,Victoria J. Fabry Department of Biological Sciences, California State University, Richard A. Feely 3 Paciﬁc Marine Environmental Laboratory, National Oceanic and Atmospheric Administration Joan A. Kleypas, Institute for the Study of Society and Environment, National Center for Atmospheric Research “Ocean acidification, the other CO2 problem” The Annual Review of Marine Science 5/2009<http://reefresilience.org/pdf/Doney_etal_2009.pdf>)

**Over the past 250 years, atmospheric carbon dioxide (CO2) levels increased by nearly 40%,** from preindustrial levels of approximately 280 ppmv (parts per million volume) to nearly 384 ppmv in 2007 (Solomon et al. 2007). **This rate of increase, driven by human fossil fuel combustion and deforestation, is at least an order of magnitude faster than has occurred for millions of years**(Doney & Schimel 2007), and **the current concentration is higher than experienced on Earth for at least the past 800,000 years** (Luthi ¨ et al. 2008). Rising **atmospheric CO2 is tempered by oceanic uptake, which accounts for nearly a third of anthropogenic carbon added to the atmospher**e (Sabine & Feely 2007, Sabine et al. 2004), and without which atmospheric CO2 would be approximately 450 ppmv today, a level of CO2 that would have led to even greater climate change than witnessed today. **Ocean CO2 uptake, however, is not benign; it causes pH reductions and alterations in fundamental chemical balances** that together are **commonly referred to as ocean acidiﬁcation. Because climate change and ocean acidiﬁcation are both caused by increasing atmospheric CO2,** acidiﬁcation is commonly referred to asthe “other CO2 problem” (Henderson 2006, Turley 2005).

#### CO2 causes ocean acification

Tedesco et. al ’05 (Kathy Tedesco, Program Manager , Richard A. Feely, Christopher L. Sabine, Catherine E, Cosca, “Impacts of Anthropogenic CO2 on Ocean Chemistry and Biology” NOAA 10/8/2005 http://www.research.noaa.gov/spotlite/spot\_gcc.html)

Recent field and laboratory studies reveal that the **carbonate chemistry of seawater has a profound negative impact on the calcification rates of individual species and communities in both planktonic (floating) and ocean bottom organisms**. The calcification **rate** of nearly all calcium-secreting organisms investigated to date decreased **in response to decreased carbonate ion concentration**. This response holds across multiple taxonomic groups from single-celled organisms to reef-building corals. **In general, when dissolved CO**2 **was increased to two times pre-industrial levels, a decrease in the calcification rate was observed, ranging from -5 to -50%.** For example, decreased carbonate ion concentration has been shown to significantly reduce the ability of reef-building corals to produce their calcium carbonate skeletons, affecting growth of individual corals and the ability of the larger reef to maintain a positive balance between reef building and reef dissolution. Scientists have also seen a reduced ability to produce protective calcium carbonate shells in species of marine algae and planktonic molluscs, on which other marine organisms feed. Calcification probably serves multiple functions in calcifying organisms. **Decreased calcification would presumably compromise the fitness or success of these organisms and could shift the competitive advantage towards non-calcifiers. Carbonate skeletal structures are likely to be weaker and more susceptible to dissolution and erosion.** While long-term consequences are unknown, experimental results from enclosed laboratory experiments indicate that coral reef organisms do not acclimate to decreasing carbonate saturation states over several years. Thus, if **calcifying organisms cannot adapt to the changes in seawater chemistry that will occur, the geographical range of some species may be reduced or may shift latitudinally in response to rising CO**2. Based on the best available understanding, it appears that **as levels of dissolved CO**2 **in sea water rise, the skeletal growth rates of calcium-secreting organisms will be reduced as a result of the effects of dissolved CO**2 **on ocean acidity and consequently, on calcification**. **The effects** of decreased calcification in microscopic algae and animals could **impact marine food webs and, combined with other climatic changes in salinity, temperature, and upwelled nutrients, could substantially alter the biodiversity and productivity of the ocean.** As humans continue along the path of unintended CO2 sequestration in the surface oceans, **the impacts on marine ecosystems will be direct and profound.**

#### CO2 leads to ocean acidification-kills marine life

Zimmer’10(“An ominous warning on the effects of ocean acidification” Yale environment 360 2/15/2010 Carl Zimmer http://e360.yale.edu/feature/an\_ominous\_warning\_on\_the\_\_effects\_of\_ocean\_acidification/2241/)

Today, Ridgwell and Daniela Schmidt, also of the University of Bristol, [are publishing a study in the journal *Natural Geoscience*](http://www.nature.com/ngeo/journal/vaop/ncurrent/abs/ngeo755.html), comparing what happened in the oceans 55 million years ago to what the oceans are experiencing today. Their research supports what other researchers have long suspected: **The acidification of the ocean today is bigger and faster than anything geologists can find in the fossil record over the past 65 million years.** Indeed, its speed and strength — Ridgwell estimate that **current ocean acidification is taking place at ten times the rate that preceded the mass extinction 55 million years ago** — **may spell doom for many marine species, particularly ones that live in the deep ocean**. “This is an almost unprecedented geological event,” says Ridgwell. When we humans burn fossil fuels, we pump carbon dioxide into the atmosphere, where the gas traps heat. But **much of that carbon dioxide does not stay in the air. Instead, it gets sucked into the oceans**. If not for the oceans, climate scientists believe that the planet would be much warmer than it is today. Even with the oceans’ massive uptake of CO2, the past decade was still the warmest since modern record-keeping began. But **storing carbon dioxide in the oceans** may come at a steep cost: It **changes the chemistry of seawater.** At the ocean’s surface, seawater typically has a pH of about 8 to 8.3 pH units. For comparison, the pH of pure water is 7, and stomach acid is around 2. The pH level of a liquid is determined by how many positively charged hydrogen atoms are floating around in it. The more hydrogen ions, the lower the pH. When carbon dioxide enters the ocean, it lowers the pH by reacting with water. **The carbon dioxide we have put into the atmosphere since the Industrial Revolution has lowered the ocean pH level by .1. That may seem tiny, but it’s not**. The pH scale is logarithmic, meaning that there are 10 times more hydrogen ions in a pH 5 liquid than one at pH 6, and 100 times more than pH 7. As a result, **a drop of just .1 pH units means that the concentration of hydrogen ions in the ocean has gone up by about 30 percent in the past two centuries.**

### Carbon Sinks Internal

#### Increased CO2 causes ocean acidification

Venkataramanan and smitha ‘11(Department of Economics, D.G. Vaishnav College, Chennai, India Indian Journal of Science “Causes and effects of global warming p.226-229 March 2011 <http://www.indjst.org/archive/vol.4.issue.3/mar11-pages159-265.pdf>)

Causes of global warming: **The buildup of carbon dioxide in the atmosphere, mainly from your fossil fuel emissions, is the most significant human cause of global warming**. Carbon dioxide is released every you burn something, be it a car, airplane or coal plant. This means you must burn less fossil fuel if you want the Earth's climate to remain stable! And unfortunately, we are currently destroying some of the best known mechanisms for storing that carbon—plants. Deforestation increases the severity of global warming as well. Carbon dioxide is released from the human conversion of forests and grasslands into farmland and cities. **All living plants store carbon. When those plants die and decay, carbon dioxide is released back into the atmosphere.** As forests and grasslands are cleared for your use, enormous amounts of stored carbon enter the atmosphere. **An unstoppable feedback loop may happen if you let this continue. If the activities mentioned above warm the Earth just enough, it could cause natural carbon sinks to fail.** A "carbon sink" is a natural system that stores carbon over thousands of years. Such sinks include peat bogs and the arctic tundra. But **if these sinks destabilize, that carbon will be released, possibly causing an unstoppable and catastrophic warming of the Earth. The oceans are no longer able to store carbon as they have in the past. The ocean is a huge carbon sink, holding about 50 times as much carbon as the atmosphere. But now scientists are realizing that the increased thermal stratification of the oceans has caused substantial reductions in levels of phytoplankton, which store CO2. Increased atmospheric carbon is also causing an acidification of the ocean, since carbon dioxide forms carbonic acid when it reacts with water**. **The tiny plants of the ocean, the very bottom of that vast watery food chain, are suffering from the effects of global warming,** which means **they are becoming less able to store carbon, further contributing to climate change.** As carbon sinks fail, the amount of carbon in the atmosphere climbs!

#### Warming destroys carbon sinks-increases rate of ocean acidification

Venkataramanan and smitha ‘11(Department of Economics, D.G. Vaishnav College, Chennai, India Indian Journal of Science “Causes and effects of global warming p.226-229 March 2011 <http://www.indjst.org/archive/vol.4.issue.3/mar11-pages159-265.pdf>)

Oceans: The role of the oceans in global warming is a complex one. The **oceans serve as a sink for carbon dioxide, taking up much that would** otherwise **remain in the atmosphere,** but **increased levels of CO2 have led to ocean acidification**. Furthermore, **as the temperature of the oceans increases, they become less able to absorb excess CO2. Global warming is projected to have a number of effects on the oceans.** Ongoing e**ffects include rising sea levels due to thermal expansion and melting of glaciers and ice sheets, and warming of the ocean surface, leading to increased temperature stratification. Other possible effects include large-scale changes in ocean circulation**.

## ---Impacts---

### Coral Reefs

#### Ocean acidification hurts coral reefs

Yates and Kleypas ‘09 (Kimberly Y. Yates, Joan A. Kleypas, marine ecologist/geologist focuses on how coral reefs and other marine ecosystems are affected by changes in the Earth's atmosphere and climate. “Coral reefs and ocean acidification, Oceanagraphy p.109 <http://tos.org/oceanography/issues/issue_archive/issue_pdfs/22_4/22-4_kleypas.pdf>)

Coral reefs were one of the first ecosystems to be recognized as vulnerable to ocean acidification. To date, most scientific investigations into the **effects of ocean acidification on coral reefs have been related to the reefs’ unique ability to produce voluminous amounts of calcium carbonate.** It has been estimated that the **main reef-building organisms, corals and calcifying macroalgae, will calcify 10–50% less relative to pre-industrial rates by the middle of this century.** This **decreased calcification is likely to affect their ability to function within the ecosystem and will almost certainly affect the workings of the ecosystem itself.** However, **ocean acidification affects not only** the **organisms, but also the reefs they build**. **The decline in calcium carbonate production, coupled with an increase in calcium carbonate dissolution, will diminish reef building and the benefits that reefs provide, such as high structural complexity that supports biodiversity on reefs, and breakwater effects that protect shorelines and create quiet habitats for other ecosystems, such as mangroves and seagrass beds. T**he focus on calcification in reefs is warranted, but the responses of many other organisms, such as fish, noncalcifying algae, and seagrasses, to name a few, deserve a close look as well.

#### Coral reef systems key to human survival

Green Reefs, 12 – Green Reefs environmental magazine (“About Us; Who Are We?” 4/22/12, <http://green-reefs.com/GreenReefAboutUs.html>, //JPL)

Here at Green Reefs we are dedicated to the preservation of these precious marine ecosystems known as coral reefs. We will examine the role these fragile biotopes have in our everyday life, from the food we eat to the medicines which may one day cure cancer. Not only do the reefs sustain much of human life, nearly all of aquatic life depends on these small ecosystems as well either directly or indirectly. As the effects of climate change, global warming, overfishing and overpopulation become more dangerous, the reefs find themselves more and more vulnerable. Human survival may ultimately hinge on the survival of the reef ecosystems. With that being said, reefs are home to some of the most colorful and majestic creatures in the world, as well as some of the strangest. With more biodiversity than the Amazon, new creatures are constantly being discovered. New medicines continue to be developed from venomous creatures in the seas. The oceans are becoming more impactful in human civilization. Despite this, the ocean remains relatively unexplored, even though it covers nearly three quarters of our planet. Scientists know more about the surface of the moon than the ocean floor.

### EXT Coral Reefs

#### Climate change destroys coral reefs – multiple reasons

GBRMPA, 11 (Great Barrier Reef Marine Park Authority, “Climate change impacts on coral reefs,” Australian Government, 8/8/11, http://www.gbrmpa.gov.au/outlook-for-the-reef/climate-change/what-does-this-mean-for-habitats/coral-reefs, //JPL)

**Coral reefs are highly vulnerable to climate change and the impacts will be far reaching. Coral reefs are complex structures** built mainly from the calcium carbonate (limestone) skeletons laid down by hard corals. These **reef-building corals are highly vulnerable to rising sea temperatures and ocean acidification**. **Slowed growth and loss of hard corals will reduce essential habitat for many other reef creatures. Reef structures** themselves **will** also **begin to crumble** if reef growth does not keep pace with erosion by animals and storms. **Coral reefs** comprise only six per cent of the area of the Great Barrier Reef, yet they **provide critical habitat and food for many species in the ecosystem**. Healthy coral reefs are also the essential foundation for reef-based tourism and fishing. **They are vitally connected to other** Great Barrier Reef **habitats** including mangroves and salt marshes, seagrass meadows, estuaries, **and open water environments**. Reefs also act as barriers, protecting inshore habitats and human communities from large waves and storm surges. Rising sea temperature **Hard corals are highly susceptible to coral bleaching caused by higher-than-normal sea temperatures. Coral bleaching is expected to occur more often and with greater severity in the future, making it difficult for corals to recover between bleaching events**. As a result, the **abundance of living corals on reefs is likely to decline** in coming decades. Some coral types, such as staghorn corals, are especially sensitive to bleaching, and these will be the most seriously affected. Coral communities will increasingly be dominated by types that are more tolerant to temperature stress. Large, fleshy **seaweeds** (macroalgae), **which compete with corals for space on the reef, will** also **benefit from rising temperatures** and coral bleaching. Scientists have shown that degrading reefs can be rapidly overgrown by these macroalgae, which in turn impede coral recovery. Reefs dominated by macroalgae and bleaching-resistant corals have less three-dimensional structure than healthy coral reefs. Such reefs provide fewer shelters and refuges for the many animals that rely on the reef for their habitat. Ocean acidification Coral reefs are also highly vulnerable to ocean acidification. Hard corals and many other organisms that contribute to reef building, such as coralline algae, make their skeletons from calcium carbonate (limestone). **The rate of skeleton formation**, known as calcification, **will slow if waters become more acidic and the skeletons of these animals and plants will be weaker**. **Reefs are continually worn down by storms**, and creatures that eat, burrow or dissolve their way through limestone. For a healthy reef to be maintained, the growth of corals and encrusting algae has to at least keep pace with this erosion. **Continuing ocean acidification will** ultimately **contribute to coral loss, and a weakening and collapse of** limestone **reef structures**. Extreme weather events The Great Barrier Reef has adapted to cope with the impacts of cyclones and severe storms. However, **many scientists predict that intense cyclones** (such as cyclone Hamish and cyclone Yasi) **will occur more often due to climate change. Reef recovery from such severe storms is slow**, because fewer corals survive to recolonise affected areas. **An increase in severe cyclones could therefore contribute to the degradation of reefs structures already weakened by coral bleaching and ocean acidification**.

### Economy

#### Ocean acidification turns the global economy and also causes mass decrease in the situation of developing countries and impoverished individuals

ESF 9 – European Science Foundation report that was coauthored by 34 scientists from a wide variety of fields (2009, “Impacts of Ocean Acidification,” <http://www.us-ocb.org/publications/ESF_SPB37_Impacts-of-Ocean-Acidification.pdf)JCP>

Socio-economic impacts: **Economic and societal impacts of ocean acidification on fish, shellfish stocks and coral reefs, and related services**. **Ocean acidification is expected to have impacts on several economically important marine resources**, including fish stocks, shellfish, and coral reefs. **Impacts on human societies will depend on the vulnerability, resilience and adaptation capacity of specific communities**. The assessment of ocean acidification impacts should be conducted using a Total Economic Value framework, which considers use (direct and indirect) and non-use values of the resources damaged**. It should be noted that socio-economic consequences of the combined impact of global warming and ocean acidification will probably become relevant before the possible damage of ocean acidification alone is fully expressed.** Direct impacts of ocean acidification on fisheries resources and the human communities they support are largely unknown. **The total economic value generated by fisheries around the world comes from both capturing wild fish and from aquaculture**. The combined value of wild capture and aquaculture is presently **around $150 billion/yr**. Whereas some unknown fraction of the economic value of fisheries might be at risk from ocean acidification, other factors such as fishing pressure, co-determine the state of fish stocks. There is a need for multi-disciplinary research, linking marine biology and fisheries economics, to assess the scale of impacts to fisheries. Fisheries management models including the effect of ocean acidification should be developed. **A better understood consequence of ocean acidification is the reduction of calcium carbonate precipitation by shells of marine organisms, including commercially valuable shellfish, crustaceans and corals**. **The economic value of coral reefs is primarily linked to their function as a habitat and nursery for commercial fish stocks, acting as a natural barrier for coastlines, and for the provision of recreation and tourism opportunities. Assuming a conservative value of $100000/km2 / yr, the global economic value associated with reefs is in the order of $30 billion/yr**. **Since ocean acidification is expected to impact a major part of these reefs within this century, it is plausible that the loss of coral reefs will amount to a loss of tens of billions of dollars per year.** **The economic value of damage to coral reefs due to ocean acidification has recently been estimated** for the first time 24 **and losses were found to be of the order of 0.18% of global GDP in 2100**. This is one order of magnitude smaller than the estimated impact of climate change but still represents **a substantial economic loss**. Further research is required to refine these damage estimates and to extend the scope of analysis beyond coral reefs to other potentially impacted marine resources. Similarly, a recent case study of the evolution of US commercial fishery revenues, focusing especially on mollusks, indicated that **substantial revenue declines, job losses, and indirect economic costs may occur due to ocean acidification**, and proposed possible adaptation strategies designed to support **fisheries and marine-resource-dependent communities**, many of which **already possess little economic resilience. An important aspect of these damage estimates is their distribution across populations**, regions and countries. **Economic losses from ocean acidification, like many other effects of climate change, fall disproportionally on the residents of developing countries**. Fish provides more than 20% of the protein for more than 2.6 billion people (FAO estimates, 2007), but is much more important in the developing countries where people still rely on reef fisheries and shellfish collecting. **Similarly, coral reefs are generally located in developing countries and provide important ecosystem services for poor coastal communities**. **Socio-economic research is required to assess the distributional consequences of ocean acidification and the impact on the livelihood of the poor**. The effect of ocean acidification on the global economy will depend on adaptations of the marine ecosystem as well as on human adaptation policies. Both are difficult to anticipate, making it difficult to calculate economic impact. **A collaboration of natural and social sciences is required to research the potential for adaptation in both ecosystems and human systems, and the interplay between the two. The costs of adapting to ocean acidification need to be assessed.**

#### Economic decline triggers nuclear war

Harris and Burrows 9 (Mathew, PhD European History at Cambridge, counselor in the National Intelligence Council (NIC) and Jennifer, member of the NIC’s Long Range Analysis Unit “Revisiting the Future: Geopolitical Effects of the Financial Crisis” <http://www.ciaonet.org/journals/twq/v32i2/f_0016178_13952.pdf>, AM)

Increased Potential for Global Conflict Of course, the report encompasses more than economics and indeed believes the future is likely to be the result of a number of intersecting and interlocking forces. With so many possible permutations of outcomes, each with ample Revisiting the Future opportunity for unintended consequences, there is a growing sense of insecurity. Even so, history may be more instructive than ever. While we continue to believe that the Great Depression is not likely to be repeated, the lessons to be drawn from that period include the harmful effects on fledgling democracies and multiethnic societies (think Central Europe in 1920s and 1930s) and on the sustainability of multilateral institutions (think League of Nations in the same period). There is no reason to think that this would not be true in the twenty-first as much as in the twentieth century. For that reason, the ways in which the potential for greater conflict could grow would seem to be even more apt in a constantly volatile economic environment as they would be if change would be steadier. In surveying those risks, the report stressed the likelihood that terrorism and nonproliferation will remain priorities even as resource issues move up on the international agenda. Terrorism’s appeal will decline if economic growth continues in the Middle East and youth unemployment is reduced. For those terrorist groups that remain active in 2025, however, the diffusion of technologies and scientific knowledge will place some of the world’s most dangerous capabilities within their reach. Terrorist groups in 2025 will likely be a combination of descendants of long established groups\_inheriting organizational structures, command and control processes, and training procedures necessary to conduct sophisticated attacks\_and newly emergent collections of the angry and disenfranchised that become self-radicalized, particularly in the absence of economic outlets that would become narrower in an economic downturn. The most dangerous casualty of any economically-induced drawdown of U.S. military presence would almost certainly be the Middle East. Although Iran’s acquisition of nuclear weapons is not inevitable, worries about a nuclear-armed Iran could lead states in the region to develop new security arrangements with external powers, acquire additional weapons, and consider pursuing their own nuclear ambitions**.** It is not clear that the type of stable deterrent relationship that existed between the great powers for most of the Cold War would emerge naturally in the Middle East with a nuclear Iran. Episodes of low intensity conflict and terrorism taking place under a nuclear umbrella could lead to an unintended escalation and broader conflict if clear red lines between those states involved are not well established. The close proximity of potential nuclear rivals combined with underdeveloped surveillance capabilities and mobile dual-capable Iranian missile systems also will produce inherent difficulties **in achieving reliable indications and warning of an impending nuclear attack**. The lack of strategic depth in neighboring states like Israel, short warning and missile flight times, and uncertainty of Iranian intentions may place more focus on preemption rather than defense, potentially leading to escalating crises. 36 Types of conflict that the world continues to experience, such as over resources, could reemerge, **particularly if** protectionism grows and there is a resort to neo-mercantilist practices. Perceptions of renewed energy scarcity will drive countries to take actions to assure their future access to energy supplies. In the worst case, this could result in interstate conflicts if government leaders deem assured access to energy resources, for example, to be essential for maintaining domestic stability and the survival of their regime. Even actions short of war, however, will have important geopolitical implications. Maritime security concerns are providing a rationale for naval buildups and modernization efforts, such as China’s and India’s development of blue water naval capabilities. If the fiscal stimulus focus for these countries indeed turns inward, one of the most obvious funding targets may be military. Buildup of regional naval capabilities could lead to increased tensions, rivalries, and counterbalancing moves, but it also will create opportunities for multinational cooperation in protecting critical sea lanes. With water also becoming scarcer in Asia and the Middle East, cooperation to manage changing water resources is likely to be increasingly difficult both within and between states in a more dog-eat-dog world.

### Generic

#### Ocean acidification kills off multiple key species- coral reefs, oysters, salmon- prefer the qual’s and recency of this evidence

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High levels of pollution may be turning the planet's oceans acidic at a faster rate than at any time in the past 300 million years, with unknown consequences for future sea life, researchers said Thursday. The acidification may be worse than during four major mass extinctions in history when natural pulses of carbon from asteroid impacts and volcanic eruptions caused global temperatures to soar, said the study in the journal Science. An international team of researchers from the United States, Britain, Spain, Germany and the Netherlands examined hundreds of paleoceanographic studies, including fossils wedged in seafloor sediment from millions of years ago. They found only one time in history that came close to what scientists are seeing today in terms of ocean life die-off -- a mysterious period known as the Paleocene-Eocene Thermal Maximum about 56 million years ago. Though the reason for the carbon upsurge back then remains a source of debate, scientists believe that the doubling of harmful emissions drove up global temperatures by about six degrees Celsius and caused big losses of ocean life. Oceans are particularly vulnerable because they soak up excess carbon dioxide from the air which turns the waters more acidic, a state that can kill corals, mollusks and other forms of reef and shell organisms. "We know that life during past ocean acidification events was not wiped out -- new species evolved to replace those that died off," said lead author Barbel Honisch, a paleoceanographer at Columbia University's Lamont-Doherty Earth Observatory. "But if industrial carbon emissions continue at the current pace, we may lose organisms we care about -- coral reefs, oysters, salmon." Honish and colleagues said the current rate of ocean acidification is at least 10 times faster than it was 56 million years ago. "The geological record suggests that the current acidification is potentially unparalleled in at least the last 300 million years of Earth history, and raises the possibility that we are entering an unknown territory of marine ecosystem change," said co-author Andy Ridgwell of Bristol University. The UN Environment Program released a report in 2010 that warned carbon emissions from fossil fuels may bear a greater risk for the marine environment than previously thought. Rising acidity levels have an impact on calcium-based lifeforms, ranging from tiny organisms called ptetropods that are the primary food source, to crabs, fish, lobsters and coral, it said. The UN report called for cuts in human-made CO2 emissions to reduce acidification and support for further work to quantify the risk and identify species that could be most in peril.

#### Here’s the science and empirics behind the study- there’s also an ocean acidification DA to SO2 and aerosol increase

* The boxes are either comparisons between the CO2/PH level changes of the past and what is happening now, or is a explanation of SO2 and aerosols leading to ocean acidification

Honisch et al. 12 (International science team combined to create this study (first part is their names, second block is their actual quals) - Bärbel Hönisch,1\* Andy Ridgwell,2 Daniela N. Schmidt,3 Ellen Thomas,4,5 Samantha J. Gibbs,6 Appy Sluijs,7 Richard Zeebe,8 Lee Kump,9 Rowan C. Martindale,10 Sarah E. Greene,2,10 Wolfgang Kiessling,11 Justin Ries,12 James C. Zachos,13 Dana L. Royer,5 Stephen Barker,14 Thomas M. Marchitto Jr.,15 Ryan Moyer,16 Carles Pelejero,17 Patrizia Ziveri,18,19 Gavin L. Foster,6 Branwen Williams20- 1Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA. 2School of Geographical Sciences, University of Bristol, Bristol BS8 1SS, UK. 3School of Earth Sciences, University of Bristol, Bristol, BS8 1RJ, UK. 4Department of Geology and Geophysics, Yale University, New Haven, CT 06520, USA. 5Department of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459, USA. 6Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton, Southampton SO14 3ZH, UK. 7Department of Earth Sciences, Utrecht University, 3584 CD Utrecht, Netherlands. 8School of Ocean and Earth Science and Technology, Department of Oceanography, University of Hawaii at Manoa, Honolulu, HI 96822, USA. 9Department of Geosciences, Pennsylvania State University, University Park, PA 16802, USA. 10Department of Earth Sciences, University of Southern California (USC), Los Angeles, CA 90089, USA. 11Museum für Naturkunde at Humboldt University, 10115 Berlin, Germany. 12Department of Marine Sciences, University of North Carolina–Chapel Hill, NC 27599, USA. 13Earth and Planetary Sciences Department, University of California Santa Cruz, CA 95064, USA. 14School of Earth and Ocean Sciences, Cardiff University, Cardiff CF10 3AT, UK. 15Department of Geological Sciences and Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO 80309, USA. 16University of South Florida St. Petersburg, Department of Environmental Science, Policy, and Geography, St. Petersburg, FL 33701, USA. 17Institució Catalana de Recerca i Estudis Avançats and Department of Marine Biology and Oceanography, Consejo Superior de Investigaciones Científicas, 08003 Barcelona, Catalonia, Spain. 18Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona, 01893 Barcelona, Spain. 19Department of Earth Sciences, Vrije Universiteit, 1081HV Amsterdam, Netherlands. 20W. M. Keck Science Department of Claremont McKenna College, Pitzer College, and Scripps College, Claremont, CA 91711, USA, “The Geological Record of

Ocean Acidification”, pdf)//JM

With these criteria in mind, we review (in reverse chronological order) the intervals in Earth’s history for which ocean acidification has been hypothesized, along with the evidence for independent geochemical and biotic changes. We confine this review to the past ~300 million years (My) because the earlier Phanerozoic (and beyond) lacks the pelagic calcifiers that not only provide key proxy information but also create the strong deepsea carbonate (and hence atmospheric PCO2) buffer that characterizes the modern Earth system (9). Our criteria for identifying potentially futurerelevant past ocean acidification are (i) massive CO2 release, (ii) pH decline, and (iii) saturation decline. We also discuss evidence for the time scale of CO2 release, as well as for global warming. Events are given a similarity index that is based on available geochemical data (table S1) and are indicated in Fig. 4A. Late Pleistocene deglacial transitions. The last deglaciation is the best documented past event associated with a substantive (30%) CO2 rise: 189 to 265 matm between 17.8 to 11.6 ky before the present (B.P.) (11). Boron isotope estimates from planktic foraminifers show a 0.15 T 0.05 unit decrease in sea surface pH (12) across the deglacial transition—an average rate of decline of ~0.002 units per 100 years compared with the current rate of more than 0.1 units per 100 years (table S1). Planktic foraminiferal shell weights decreased by 40 to 50% (4), and coccolith mass decreased by ~25% (13). In the deep ocean, changes in carbonate preservation (14), pH [from foraminiferal d11B (15)] and [CO2− 3 ] [from foraminiferal B/Ca and Zn/Ca (16, 17)] differed between ocean basins, reflecting covarying changes in deep-water circulation and an internal carbon shift within the ocean. The regional nature of these variations highlights the general need for careful evaluation of regional versus global effects in paleo-studies. Oligocene–Pliocene. The climate of the Oligocene to Pliocene [34 to 2.6 million years ago (Ma)] contains intervals of elevated temperature and modest deviations of atmospheric PCO2 from modern values (Fig. 4). Of particular interest has been the Pliocene warm period [3.29 to 2.97 Ma (18, 19)], which is characterized by global surface temperatures estimated to be ~2.5°C higher than today (19), atmospheric PCO2 between 330 to 400 matm (Fig. 4C) (18, 20), and sea surface pH(T) ~0.06 to 0.11 units lower (18) than the preindustrial. Ecological responses to the warming include migration of tropical foraminifer species toward the poles (21), but there are no documented calcification responses or increased nannoplankton extinction rates (22). The early to middle Miocene (23 to 11Ma) and Oligocene (34 to 23 Ma) were also characterized periods of elevated temperatures and slightly higher PCO2 compared with preindustrial values (Fig. 4C) but, because of their long duration, were not associated with changes in CaCO3 saturation (Fig. 3C). Paleocene–Eocene. Evidence for rapid carbon injection associated with the Paleocene–Eocene Thermal Maximum (PETM, 56 Ma) as well as a number of smaller transient global warming events (hyperthermals) during the late Paleocene and early Eocene (58 to 51 Ma) comes primarily from observations of large [up to –4 per mil (‰)] negative d13C excursions (23) associated with pronounced decreases in calcium carbonate preservation (24). Depending on the assumed source, rate, and magnitude of CO2 release (25), a 0.25 to 0.45 unit decline in surface seawater pH is possible, with a reduction in mean surface ocean aragonite saturation from W = 3 down to 1.5 to 2 (1). The calcite compensation depth (CCD) (8) rose by ~2 km to shallower than 1.5 km in places (24) (compared with >4 km today). Although a pH decrease or PCO2 increase remains to be confirmed by geochemical proxies for any of the hyperthermal events, the amount of carbon injected can be modeled on the basis of consistent carbonate d13C and CCD changes, yielding between ~2000 and 6000 PgC for the onset of the PETM (26, 27).However, as with the last glacial transition, deep sea geochemistry appears strongly modulated by regional ocean circulation changes (28), which adds an additional layer of complexity to global extrapolation and highlights the importance of adequate spatial coverage of the data. PETM sediments record the largest extinction among deep-sea benthic foraminifers of the past 75 My (29), and a major change in trace fossils indicates a disruption of the macrobenthic community (30). However, the covariation of ocean acidification, warming, and corresponding oxygen depletion (fig. S2) (23) precludes the attribution of this extinction to a single cause (1, 29). In shallow water environments, a gradual shift from calcareous red algae and corals to larger benthic foraminifers as dominant calcifiers started in the Paleocene and was completed at the PETM with the collapse of coralgal reefs and larger benthic foraminiferal turnover (31). This event is recognized as one of the four major metazoan reef crises of the past 300My (Fig. 1) (32). In marginal marine settings, coccolithophore (33) and dinoflagellate cyst (34) assemblages display changes in species composition, but these are interpreted to reflect sensitivity to temperature, salinity stratification, and/or nutrient availability (34, 35), not necessarily acidification (fig. S2). In the open ocean, the occurrence of deformities in some species of calcareous nannoplankton has been described (36), but despite a strong change in assemblages, there is no bias in extinction or diversification in favor of or against less or more calcified planktic species (37). Cretaceous and Cretaceous-Paleogene. The well-known mass extinction at 65 Ma is generally accepted to have been triggered by a large asteroid impact (38). In addition to potential terrestrial biomass or fossil carbon burning, the impact may have caused the emission of SO2 from vaporized gypsum deposits at the impact site and/or nitric acid aerosols produced by shock heating of the atmosphere, which could have led to acid rain and hence potentially to rapid acidification of the surface ocean (38). Although planktic calcifiers exhibited elevated rates of extinction and reduced production (22, 39), reef corals did not experience a major extinction (32), and benthic foraminifers were not affected in either shallow or deep waters (29). Because multiple environmental changes covaried and proxy data for marine carbonate chemistry are not yet available, unambiguous attribution of the planktic extinctions to any one driver such as ocean acidification is currently not possible. The earlier Cretaceous (K) (Fig. 4A) is generally a time of massive chalk deposition (mainly in the form of nannofossil calcite), as well as one of elevated PCO2 (Fig. 4B) and lower pH (Fig. 4D). This association can be misconceived as evidence that marine calcification will not be impaired under conditions of low pH in the future. However, this reasoning is invalid because extended periods of high PCO2 (Fig. 4B) do not necessarily result in a suppressed seawater calcite saturation state (Fig. 3) (1, 40), which exerts an important control on organisms’ calcification (41). Cretaceous and Jurassic oceanic anoxic events. The Mesozoic oceanic anoxic events (OAEs) (in particular, OAE 2 ~93 Ma, OAE1a ~120 Ma, and Toarcian OAE ~183 Ma) were intervals during which the ocean’s oxygen minimum and deep anoxic zones expanded markedly (42). The onsets of these OAEs have been linked to the emplacement of large igneous provinces, degassing large amounts of CO2 and associated environmental consequences of warming, lower oxygen solubility, and possibly ocean acidification (42). Some of the Cretaceous OAEs were associated with turnover in plankton communities (43). Deformities and some minor size reduction in coccoliths, as well as a massive increase in the abundance of heavily calcified nannoconids, have been observed (44, 45). However, similar to more recent events, there is difficulty in unequivocally attributing observations to surface water acidification given the covariation of environmental changes (46). Because most old sea floor (~180 Ma or older) is subducted, the sedimentary record of the Toarcian OAE is now restricted to former continentalmargins. Sedimentary organic and inorganic carbon deposits display initially negative, followed by positive d13C excursions, which is consistent with an influx of CO2 into the atmosphere followed by organic carbon burial (42). The negative isotopic transition occurs in distinct negative d13C shifts, each estimated to occur in less than 20 ky (47) and possibly in as little as 650 years (48). The Toarcian OAE is associated with a reef crisis that was particularly selective against corals and hypercalcifying sponges (animals with a large skeletal-to– organic biomass ratio) (Fig. 4B) (32) and with a decrease in nannoplankton flux (49). Again, these observations could have been a response to any one or combination of a number of different contemporaneous environmental changes. Triassic–Jurassic. The Triassic–Jurassic (T/J) mass extinction is linked to the coeval emplacement of the Central Atlantic Magmatic Province (50). Proxy records across the T/J boundary (~200 Ma) suggest a doubling of atmospheric PCO2 over as little as 20 ky (51, 52), although the absolute PCO2 estimates differ greatly between proxies, with leaf stomata suggesting an increase from 700 to 2000 matm, whereas pedogenic carbonates indicate an increase from 2000 to 4400 matm (Fig. 4C) (2). Decreased carbonate saturation is inferred from reduced pelagic carbonate accumulation in shelf sediments (53), although shallow water carbonate deposition can vary in response to many parameters, not only acidification. A calcification crisis amongst hypercalcifying taxa is inferred for this period (Fig. 4B), with reefs and scleractinian corals experiencing a neartotal collapse (32). However, the observation that tropical species were more affected than extratropical species suggests that global warming may have been an important contributor or even dominant cause of this extinction (32). Permian–Triassic. The Permo–Triassic (P/T) mass extinction (252.3 Ma) was the most severe of the Phanerozoic Era and coincided, at least in part, with one of the largest known continental eruptions, the Siberian trap basalts. Recent estimates for the total CO2 release put it at ~13,000 to 43,000 PgC in 20 to 400 ky (54–56)—an annual carbon release of ~0.1 to 1 PgC [compared with 9.9 PgC in 2008 (57)]. There is some observational evidence for carbonate dissolution in shelf settings (54), but its interpretation is again debated (58). There is abundant evidence for ocean anoxia, photic zone euxinia (enrichment in hydrogen sulfide) (59), and strong warming (54), but no direct proxy evidence for pH or carbonate ion changes. Knoll et al. (59) inferred the preferential survival of taxa with anatomical and physiological features that should confer resilience to reduced carbonate saturation state and hypercapnia (high CO2 in blood) and preferential extinction of taxa that lacked these traits, such as reef builders (32).

#### Ocean acidification is happening now and threatens marine ecosystems- you should err on the side of caution, we can’t predict all the impacts of acidification

Roberts 5/14 (Callum Roberts- marine conservation biologist, oceanographer, author and research scholar at the University of York, England, May 14 2012, “‘The Ocean of Life’—And the Sorrow Beneath the Sea”, http://www.thedailybeast.com/newsweek/2012/05/13/the-ocean-of-life-and-the-sorrow-beneath-the-sea.html)//JM

The oceans have absorbed around 30 percent of the carbon dioxide released by human activity since pre-industrial times, mainly from fossil-fuel burning, conversion of forests and swamp to cities and agriculture, and cement production. If carbon-dioxide emissions are not curtailed, ocean acidity is expected to rise 150 percent by 2050, the fastest rate of increase at any time in at least the last 20 million years and probably as long as 65 million years, which takes us back to the age of dinosaurs. As Carol Turley, an expert on ocean acidification from Plymouth Marine Laboratory put it, “the present increase in ocean acidity is not just unprecedented in our lifetimes, it is a rare event in the history of the planet.” The effects of acidification are hard to predict. At the very least life is likely to get much more difficult for species with carbonate shells, which includes some of the most important primary producers in the sea, the phytoplankton that sustain food webs and release life-giving oxygen. Any fall in the rate of plankton production would reduce the snow of organic debris that sinks from sunlit surface layers to the deep sea. Deep-sea communities survive on meager handouts from above, and failure in supply would shrink their numbers.

#### Increase in CO2 leads to extinction

Briggs’05 (“Boost to CO2 Mass Extinction idea” BBC Helen Briggs <http://news.bbc.co.uk/2/hi/science/nature/4184110.stm>)

The NCAR team used a research tool known as the Community Climate System Model (CSSM) which looks at the combined effects of atmospheric temperatures, ocean temperatures and currents. Their work indicates that t**emperatures in higher latitudes rose so much that the oceans warmed to a depth of about 3,000m** (10,000ft). This **interfered with the circulation process that takes colder water, carrying oxygen and nutrients, into lower levels. The water became depleted of oxygen and was unable to support marine life.** "The implication of our study is that **elevated CO2 is sufficient to lead to inhospitable conditions for marine life and excessively high temperatures over land would contribute to the demise of terrestrial life,"** Jeffrey Kiehl and colleagues write in Geology.

#### High levels of CO2 lead to mass extinctions

Parry‘ 12(Live Science Senior writer“Oceans turning acidic faster than in than psat 300 million years” Wayne Parry Live Science 3/2/2012 http://www.livescience.com/18786-ocean-acidification-extinction.html)

**The oceans are becoming more acidic faster than they have in the past 300 million years, a period that includes four mass extinctions**, researchers have found. Then, as is happening now, **increases in carbon dioxide in the atmosphere warmed the planet and made the oceans more acidic. These changes are associated with major shifts in climate and mass extinctions.** But while past increases in the atmosphere's carbon dioxide levels resulted from volcanoes and other natural causes, today **that spike is due to human activities,** the scientists note. "What we're doing today really stands out," lead researcher Bärbel Hönisch, a paleoceanographer at Columbia University's Lamont-Doherty Earth Observatory, said in a news release. "We know that life during past ocean acidification events was not wiped out — new species evolved to replace those that died off. But **if industrial carbon emissions continue at the current pace, we may lose organisms** we care about — coral reefs, oysters, salmon." [Humans Causing 6th Mass Extinction] **As the level of carbon dioxide in the atmosphere increases, oceans absorb that carbon dioxide,** which turns into a carbon acid. As a result the pH — a measure of acidity — drops, meaning **the water has become more acidic.** This dissolves the carbonates needed by some organisms, like corals, oysters or the tiny snails salmon eat. **In their review, published Thursday (March 1) in the journal Science, Hönisch and colleagues found the closest modern parallel about 56 millions ago** in what is called the Paleocene-Eocene Thermal Maximum, w**hen atmospheric carbon concentrations doubled, pushing up global temperatures. Extinctions in the deep sea accompanied this shift.** (The PETM occurred about 9 million years after the dinosaurs went extinct.) **But, now, the ocean is acidifying at least 10 times faster than it did 56 million years ago**, according to Hönisch. Ocean acidification may also have occurred when volcanoes pumped massive amounts of carbon dioxide into the air 252 million years ago, at the end of the Permian period, and 201 million years ago, at the end of the Triassic period, they found. Both are associated with mass extinctions. **"The current rate of (mainly fossil fuel) carbon dioxide release stands out as capable of driving a combination and magnitude of ocean geochemical changes potentially unparalleled in at least the last 300 million years of Earth history, raising the possibility that we are entering an unknown territory of marine ecosystem change,"** the researchers conclude in their paper.

#### Acidification results in extinction

Sify 2010 – Sydney newspaper citing Ove Hoegh-Guldberg, professor at University of Queensland and Director of the Global Change Institute, and John Bruno, associate professor of Marine Science at UNC (Sify News, “Could unbridled climate changes lead to human extinction?”, <http://www.sify.com/news/could-unbridled-climate-changes-lead-to-human-extinction-news-international-kgtrOhdaahc.html>

The findings of the comprehensive report: **'The impact of climate change** on the world's marine ecosystems' **emerged from a synthesis of recent research on the world's oceans, carried out by two of the world's leading marine scientists**. One of the authors of the report is Ove Hoegh-Guldberg, professor at The University of Queensland and the director of its Global Change Institute (GCI). **'We may see sudden, unexpected changes that have serious ramifications** for the overall well-being of humans, **including the capacity of the planet to support people.** This is further **evidence that we are well on the way to** the next great **extinction** event,' says Hoegh-Guldberg. 'The findings have enormous implications for mankind, particularly **if the trend continues. The** earth's **ocean, which produces half of the oxygen we breathe and absorbs 30 per cent of human-generated carbon dioxide,** is equivalent to its heart and lungs. This study **shows** worrying **signs of ill-health**. It's as if the earth has been smoking two packs of cigarettes a day!,' he added. 'We are entering a period in which the ocean services upon which humanity depends are undergoing massive change and in some cases beginning to fail', he added. The 'fundamental and comprehensive' **changes** to marine life identified in the report **include rapidly warming and acidifying oceans, changes in water circulation and expansion of dead zones** within the ocean depths. These are driving major changes in marine ecosystems: **less** abundant coral **reefs**, sea grasses and **mangroves** (important **fish** nurseries); fewer, smaller fish; a **breakdown in food chains**; changes in the distribution of marine life; **and more** frequent **diseases and pests** among marine organisms. Study co-author John F Bruno, associate professor in marine science at The University of North Carolina, says **greenhouse gas emissions are modifying many physical and geochemical aspects** of the planet's oceans, **in ways 'unprecedented** in nearly a million years'. 'This is causing fundamental and comprehensive changes to the way marine ecosystems function,' Bruno warned, according to a GCI release. These findings were published in Science

#### Unmitigated carbon emissions cause extinction- ocean acidification

Joe Romm 12 is a Fellow at American Progress and is the editor of Climate Progress, “Science: Ocean Acidifying So Fast It Threatens Humanity’s Ability to Feed Itself,” 3/2/2012, http://thinkprogress.org/romm/2012/03/02/436193/science-ocean-acidifying-so-fast-it-threatens-humanity-ability-to-feed-itself/?utm\_source=feedburner&utm\_medium=email&utm\_campaign=Feed%3A+climateprogre

**The world’s oceans may be turning acidic faster** today **from human carbon emissions** than they did during four major extinctions in the last 300 million years, when natural pulses of carbon sent global temperatures soaring, says a new study in Science. The study is the first of its kind to survey the geologic record for evidence of ocean acidification over this vast time period. “What we’re doing today really stands out,” said lead author Bärbel Hönisch, a paleoceanographer at Columbia University’s Lamont-Doherty Earth Observatory. “We know that life during past ocean acidification events was not wiped out—new species evolved to replace those that died off. But **if industrial carbon emissions continue at the current pace, we may lose organisms we care about**—coral reefs, oysters, salmon.” That’s the news release from a major 21-author Science paper, “The Geological Record of Ocean Acidification” (subs. req’d). We knew from a 2010 Nature Geoscience study that the oceans are now acidifying 10 times faster today than 55 million years ago when a mass extinction of marine species occurred. But this study looked back over 300 million and found that “**the unprecedented rapidity of CO2 release currently taking place” has put marine life at risk in a frighteningly unique way: … the current rate of (mainly fossil fuel) CO2 release stands out as capable of driving a combination and magnitude of ocean geochemical changes potentially unparalleled in** at least the last ~300 My of **Earth history**, raising the possibility that **we are entering an unknown territory** of marine ecosystem change. That is to say, it’s not just that acidifying oceans spell marine biological meltdown “by end of century” as a 2010 Geological Society study put it. **We are also warming the ocean and decreasing dissolved oxygen concentration. That is a recipe for mass extinction.** A 2009 Nature Geoscience study found that **ocean dead zones** “devoid of fish and seafood” **are poised to expand and “remain for thousands of years.“** And remember, we just learned from a 2012 new Nature Climate Change study that **carbon dioxide is “driving fish crazy” and threatening their survival**. Here’s more on the new study: The oceans act like a sponge to draw down excess carbon dioxide from the air; the gas reacts with seawater to form carbonic acid, which over time is neutralized by fossil carbonate shells on the seafloor. But **if CO2 goes into the oceans too quickly, it can deplete the carbonate ions that corals, mollusks and some plankton need for reef and shell-building.**

#### Ocean acidification is happening now and will cause extinction if we don’t reduce carbon emissions – dead-zones, fish-breeding, plankton deaths, invasive species and food-chain collapse mean that it’s on par with nuclear war and impossible to adapt to

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They are calling it “the other CO2 problem”. Its victim is not the polar bear spectacularly marooned on a melting ice floe, or an eagle driven out of its range, nor even a French pensioner dying of heatstroke. What we have to mourn are tiny marine organisms dissolving in acidified water. In fact we need to do rather more than just mourn them. We need to dive in and save them. **Suffering plankton may not have quite the same cachet as a 700-kilo seal-eating mammal, but their message is no less apocalyptic. What they tell us is that the chemistry of the oceans is changing, and that, unless we act decisively, the limitless abundance of the sea within a very few decades will degrade into a useless tidal desert. In every way — economically, environmentally, socially — the effects of ocean acidification are as dangerous as climate change, and even harder to resist**. It has been a slow dawning. Until recently, marine scientists have had little luck in engaging the public or political mind. **The species most directly at risk — plankton, corals, sea snails, barnacles and other stuff that most people have never heard of — seemed as remote from our lives as cosmic dust**. But now at last “the other CO2 problem” may have found a mascot of its own — the tiny but colourful clownfish, winsome star of the Disney classic Finding Nemo. In the film, Nemo gets lost. **Now it turns out that real clownfish might lose their way too.** In early February, the American academic journal Proceedings of the National Academy of Sciences (PNAS) carried a paper titled “**Ocean acidification impairs olfactory discrimination and homing ability of a marine fish”.** The sombre language concealed a stark message. What the researchers had found was that **clownfish larvae in acidified water were unable to detect the odours from adult fish that led them to their breeding sites. The implications were obvious. If the fish don’t breed, the species will not survive, and what is true for one species must be true for others**. In time, **the world’s fishing fleets will be less a food resource than a disposal problem.** What’s happening is this: **the oceans absorb carbon dioxide (**CO2) from the atmosphere. As most climate scientists and governments now agree, human activity — most importantly, **burning fossil fuels — has intensified CO2 in the atmosphere**, causing long-term climate change. The good thing is that the seas have absorbed a lot of the gas and so have slowed the pace of atmospheric warming. The bad thing is that **CO2 reacts with sea water to make carbonic acid.** Since 1800, humans have generated 240 billion tonnes of carbon dioxide, half of which has been absorbed by the sea. On average, each person on Earth contributes a tonne of carbon to the oceans every year. **The result is a rapid rise in acidity** — or a reduction in pH, as the scientists prefer to express it — **which, as it intensifies, will mean that marine animals will be unable to grow shells, and that many sea plants will not survive. With these crucial links removed, and the ecological balance fatally disrupted, death could flow all the way up the food chain, through tuna and cod to marine mammals and Homo sapiens. As more than half the world’s population depends on food from the sea for its survival, this is no exaggeration**. This is why 155 marine scientists from 26 countries recently signed the Monaco Declaration, identifying the twin threats of global warming and ocean acidification as “the challenge of the century”. It is, nevertheless, a challenge they have taken up only recently. “The whole scientific community was caught with its pants down,” says Jason Hall-Spencer, research lecturer at Plymouth University, who was one of the signatories. The term “ocean acidification” was coined only in 2003 — by odd coincidence the same year Finding Nemo was released and 35,000 people died in the European summer heat wave — though, unlike global warming, it has not had to face the opposition of truth-deniers. Verging on panic in 2005, the Royal Society published a 68-page report in which it calculated that acidification had increased by 30% in 200 years. If we went on as we were, it said, this would rise to 300% by 2100, making the seas more corrosive than they had been at any time for hundreds of millennia. In every practicable sense, the damage was irreversible. “**It will take tens of thousands of years for ocean chemistry to return to a condition similar to that occurring at pre-industrial times,”** the Royal Society said. It is a truism that might have been minted for the Darwin bicentenary. **A species once lost is gone for ever. You can’t rewind evolution, or reinvent fish**. We are not talking about dispossessing our children, or even our grandchildren’s grandchildren. **We are talking so many generations into the fog of geological time that we might not even be talking about the same species.** We are certainly not talking about low-lying countries protected by coral reefs**,** such as the Maldives. In future they will not be studying the marine environment: they will be part of it. Doomy stuff like this, of course, is nothing new. The “warmists”, as the deniers like to call them, have been telling us for years that our rate of consumption is unsustainable and that future generations will pay a terrible price for our carelessness. **If you don’t want to believe in climate change, you can argue that forecasts created by computer modelling are “theoretical”. Or you can confuse the long-term graph of “climate” with the short-term spikes of “weather**”. Look, there’s a snowflake! Global warming can’t be happening! **But acidification permits no such equivocation. It is demonstrable, visible and measurable, and there is nothing theoretical about how it is caused or what it does.** All the same, until now there has been one significant shortcoming**.** As with the clownfish, it has been easy enough under laboratory conditions to see how individual species respond to acidity. What is much less easy is to observe the effects on entire ecosystems. This problem has now been cracked by a team from Plymouth led by Jason Hall-Spencer, who scanned the world for a location where the sea conditions expected in future were already happening naturally. They found it in the Bay of Naples, just off the holiday island of Ischia. The sea bed here is chalk. Deep geological activity converts some of this into carbon dioxide and forces it up through volcanic vents into the water. In and around the neighbourhood of these vents, the result is a perfect “gradient” of pH levels from the normal 8.1 all the way down to 7.4 (remember: the lower the pH, the higher the acidity). To non-scientists, the giving or taking of a few decimal points can look undramatic. To experts they mark the difference between life and death. **The 30% increase in acidity during the industrial age is reflected by a drop in pH of just 0.1. On current trends, it will plummet by another 0.4 points to hit an unprecedented low of 7.7 by 2100**. By 2300 it could be down to 7.3. **Few species living in the sea have experienced conditions like these at any time throughout their entire life on Earth.** **With pH as low as this, it is at least questionable that land creatures** emerging from the primal swamp **could have evolved into the bony specimens that roam the Earth today. And it is certain that the pace of environmental change is far too fast for evolution to keep in step. As a recipe for life on Earth, it is about as efficacious as nuclear war**. Experiments have shown that **the tipping point at which shell growth ceases comes at a pH of 7.8.** This is the level which, on current trends, will be the global norm before the end of the century, and it is the level at which the Plymouth team has focused its attention. Given all the dire warnings, the first visual impression at Ischia is something of a surprise. There are plenty of fish. Is it, then, a false alarm? Could the world’s scientists have got their statistical knickers in a twist and jumped to a false conclusion? Will life just go on as normal? Alas, no. **The acidified water is a small zone in a wider sea. There is no barrier**. The fish are just visitors. They come to feed on the soft-bodied algae that survive in the altered conditions, then they swim away again. **What they don’t do is breed — which is exactly what the Nemo research predicts**. “**Fish breed naturally at a pH of 8.1,”** says Hall-Spencer. He believes the sensory loss observed in clownfish is only one part of the story. “**Losing the sense of smell,” he says, “is not likely to be the only effect. It’s much more likely to be one impairment among many. Eggs in these conditions cannot develop normally**.” Shelled creatures in the Ischian waters are visibly suffering. **Sea urchins thin out and disappear as the acidity increases; so do corals, limpets and barnacles.** Sea snails straying into the zone have thin, weak shells, and produce no young. **There is another important absentee, too — the coralline algae (seaweed with a chalk skeleton) that glues coral reefs together. Without it, reefs become weakened and fall apart**. In just a few decades, **if the output of carbon dioxide does not abate, this will be the condition of all the world’s oceans**. Many if not all commercially fished species, including shellfish, will suffer. So, too, will coral reefs, whose disintegration will leave low-lying coasts in the tropics unprotected from the rising seas and fiercer storms that climate change will unleash. **By some calculations reefs will have vanished by 2065**, and nobody expects them to survive into the 22nd century. Nature, however, will continue to abhor a vacuum. **Species that disappear will be replaced by alien invaders**. Shelled and vertebrate creatures will be replaced by the soft and the blobby. **Celebrity chefs, if they survive** as a species, **will be teaching us how to stuff jellyfish**. The plant species that thrive around the volcanic vents in the Bay of Naples are alien to the Mediterranean, laying the foundations of an entirely different ecosystem. **Already**, says Hall-Spencer, similar **changes are occurring along the southern coasts of England**. Oyster farmers and ships discharging ballast water have accidentally introduced Japweed, **Sargassum muticum**, a fast-growing brown seaweed that clogs beaches and harbours. Originally a native of southeast Asia and Japan, **it is unfazed by low pH and almost impossible to eradicate**. As in the classic case of the grey squirrel ousting the red, the **invasive alien expels and replaces the natives.** “It perturbs the ecosystem and drives out things that should live there,” says Hall-Spencer. **Plants are the base of the food chain, so everything in the water depends on them directly or indirectly**. With the professional caution of the scientist, he declines to speculate on which species will be the first to disappear, but acknowledges that **many creatures have little hope of survival**. To reprise the old Star Trek mantra, **there will be life here, but not life as we know it**.

#### Ocean acidification is the ‘stealth asteroid’ of climate change – it will cause extinction through a collapse of food-chains

NYT 6/25 (6/25/12, “‘Nature’s Masons’ Do Double Duty as Storytellers,” <http://www.nytimes.com/2012/06/26/science/natures-masons-do-double-duty-as-earths-storytellers.html?_r=1)JCP>

**Forams are a vital part of a “biological pump” that removes carbon dioxide from the atmosphere**. When carbon dioxide dissolves in seawater, one reaction product is carbonate**. In making their calcium carbonate shells, the large mass of so-called planktonic forams floating in the upper levels of the oceans sequester about one quarter of all carbonate produced in the oceans each year. The increasing levels of carbon dioxide in our planet’s atmosphere**, now at a greater level than at any time in the past 400,000 years, **threaten to overwhelm this biological pump by inhibiting the formation of calcium carbonate shells. As more carbon dioxide dissolves in the ocean, the waters acidify, decreasing the concentration of carbonate** and making it more difficult for these organisms to form calcium carbonate shells. **The ocean surface is now about one-tenth of a pH unit more acidic than in preindustrial times. And** indeed, a recent study of forams in the Southern Ocean found that their **shells are now 30 percent to 35 percent thinner than in the preindustrial era. As terrestrial animals, we are most focused on how climate change affects our immediate habitat. But ocean acidification may be a sort of stealth asteroid of environmental change. At current rates of carbon dioxide production, ocean acidity is projected to increase by another three- to four-tenths of a pH unit by the end of the century, with potentially catastrophic effects on shell-forming creatures and food chains. And in the present geologic period, guess who is at the top of those chains?**

### Pteropods

#### Ocean acidification kills pteropods- that collapses the entire food chain

Goldstone 11 (Heather Goldstone holds a Ph.D. in ocean science and has spent several years reporting on the Cape's unique environment and research community for the Cape and Islands NPR stations, September 15 2011, “Ocean acidification through the eyes of artists”, http://climatide.wgbh.org/2011/09/ocean-acidification-through-the-eyes-of-artists/)//JM

As carbon dioxide builds up in the atmosphere, so too in the ocean. Scientists estimate the ocean has absorbed a quarter to a third of human carbon dioxide emissions over the past two hundred years. Once in the water, that carbon dioxide undergoes some chemical transformations, the end results of which include a drop in ocean pH (known as ocean acidification) and a decrease in the availability of carbonate that many animals use to build calcium carbonate shells or skeletons. Ocean acidification already has poster children, most notably corals and oysters. But, as Dr. Gareth Lawson is quick to point out, many of the most dramatic impacts of ocean acidification will happen in the coldest parts of the open ocean, far from the prying eyes of coastal dwellers and recreational SCUBA divers. That’s where pteropods come in. Pteropods are abundant in the high latitudes of both the Atlantic and Pacific. They are an important food source for fish, from herring to salmon, mackerel to cod. Scientists worry that a collapse in pteropod numbers could mean the collapse of entire food chains. And a collapse may be possible. Pteropods thrive in the cold, Arctic waters where climate change and ocean acidification are making themselves felt most rapidly. They also make daily excursions down to depths of 500 meters or more, where waters can already border on corrosive to their delicate shells.

## ---AT: Iron Fertilization---

### Aff- Fails

#### Fertilization fails- sequesters 1/8 of the CO2 we emit, and destroys marine ecosystems

The Royal Society 9 (Yale research group, September 2009, “Geoengineering the climate Science, governance and uncertainty”, pdf)//JM

Generic limitations on fertilisation strategies The biological pump is responsible for sinking ~10 GtC/yr out of the surface layer, of which only a fraction sinks deep enough to be sequestered for centuries, as required (see Figure 1.2). If a geoengineering strategy were able to generate a sustained increase in this fi gure by 10% (which would require a massive, global-scale fertilisation programme) we could expect that at maximum, some fraction of 1 GtC/yr extra could be extracted from the atmosphere. Given that carbon is currently being released due to human activities at the rate of 8.5 GtC/yr, it is apparent that ocean fertilisation can play at best only a modest role in carbon sequestration (see Table 2.8). Its effect is on a similar scale to what might be gained by re-forestation of the land surface (Section 2.2.1), as might be expected given that the productivity of global terrestrial biota is similar to that of the oceans (Figure 1.2). Undesirable side effects All ocean fertilisation proposals involve intentionally changing the marine ecosystem, but because of its complexity the possible consequences are uncertain. In particular, the complex trophic structures typical of ocean food webs make the ecological impacts and their consequences for nutrient cycling and flow hard to predict. A few of these have been suggested as potentially advantageous (eg, the increased productivity might support a larger population of fish and/or invertebrates). However there is no reason to believe that the increased populations would be of species considered desirable by humans: experience with eutrophication in estuarine and freshwater systems suggests otherwise. In particular, there is the potential that the anoxic (oxygen-starved) regions of the ocean may increase in area because respiration of the increased biological material uses additional dissolved oxygen. This process is already occurring in some places because of nitrogen inputs from land-based sources (Diaz & Rosenberg 2008). In parallel with this is the possibility that the removal of CO2 from the atmosphere may be offset by the production of some biogenic greenhouse gases such as CH4 and N2O (Submission: Greenpeace). Thus, avoidance of negative environmental consequences could limit the scale at which ocean fertilisation could be deployed. Iron fertilisation Iron fertilisation is by far the best studied artificial ocean fertilisation technique. This is because until comparatively recently the degree to which Fe is a limiting nutrient in the oceans was controversial, and the best way of testing the ‘iron hypothesis’ was by conducting small-scale (~10 km2) releases of Fe (Martin et al. 1994). As a consequence more than a dozen such limited release experiments have been performed in the last 15 years (Boyd et al. 2007) under circumstances that might mimic a geoengineering application on a very small scale. These experiments have demonstrated only limited transient effects as increased iron led to the predicted phytoplankton bloom, but the effect is moderated either by other limiting elements, respiration or by grazing by zooplankton (Submission: ACE Research Cooperative; UK Met Office). Iron stimulates biological production chiefly in the HNLC regions of the world ocean—the Southern Ocean, equatorial Pacific and Northern Pacific. Because the nutrient-robbing effect is especially important for Fe and limits the efficiency with which carbon is removed from the atmosphere from warm water regions in particular, most studies suggest the Southern Ocean as the most efficient region to fertilise. The effects and efficacy of Fe fertilisation remain subjects for research because comparatively little is known about the biogeochemistry of iron in the oceans.

#### Scientific consensus is on our side- success is dependent on timing and location- makes wide scale CO2 reduction impossible- and it’s too early to tell if the tech really works

Cliff et al 7/19 (Dr Cliff Law, principal scientist at National Institute of Water and Atmospheric Research (NIWA), was a recipient of the 2011 Prime Minister’s Science Prize for his work on iron fertilization, Professor Philip Boyd at Otago University’s NIWA Centre for Chemical and Physical Oceanography (also a PM’s Science Price Recipient), Prof Tom Trull, Professor of Marine Biogeochemistry at CSIRO Marine and Atmospheric Research and the University of Tasmania, and leader of the Carbon Program at Australia’s Antarctic Climate and Ecosystems Cooperative Research Centre, Prof Andy Ridgwell, Professor in Earth System Modelling at the University of Bristol, Dr Michael Steinke, Lecturer in Marine Sciences at the University of Essex, Dr Dave Reay, senior lecturer in carbon management at the University of Edinburgh- ALL THESE PEOPLE GAVE COMMENTS TO SCIENCE MEDIA CENTER AFTER BEING CONTACTED BY SMC FOR RESPONSES TO RECENT EIFEX TEST RESULTS, July 19 2012, “ Posted in Science Alert: Experts Respond Get RSS of Science Alert: Experts Respond Algal blooms re-evaluated for carbon capture”, http://www.sciencemediacentre.co.nz/2012/07/19/can-algal-blooms-be-used-to-pump-carbon-to-the-ocean-depths/)//JM

Dr Cliff Law, principal scientist at National Institute of Water and Atmospheric Research (NIWA), was a recipient of the 2011 Prime Minister’s Science Prize for his work on iron fertilisation. He comments: “The paper reports on an experiment that extends the observations and understanding developed from the previous iron experiments “As a result of longer occupation on site, and a measurement framework more focussed upon particle export, than previous experiments the authors have identified that a significant proportion of the “extra” carbon fixed by the iron-fuelled phytoplankton growth is transferred into the deep ocean. “As this carbon will be isolated from the atmosphere for decades to centuries the results have implications for understanding of both past and present climate change. “That this experiment recorded a stronger phytoplankton bloom than any previous iron experiment highlights the importance of timing and location “The 12 previous experiments to date have taken place in different regions and shown a broad range of responses, with the lowest response recorded on the NZ SAGE experiment at the same time of year and same latitude (in New Zealand waters) as the experiment reported in Nature “Indeed a subsequent larger iron addition experiment carried out by Smetacek et al in the same region of the South Atlantic at the same time of year in 2009 saw only a modest increase in carbon export. “So location and timing of an iron experiment is critical. “The paper may re-open the debate around geoengineering, although the authors do not link their results to this. “ The strength of their experimental design conversely highlights the problems and limitations of larger scale iron releases (for science or geo-engineering) in that the response can only be observed, and more importantly verified to be have arisen from the iron addition, when carried out in optimal conditions such as the enclosed eddy described. “Even under these conditions the authors mention potential interference of natural blooms, and also note significant uncertainties. “Tracking the response to iron addition is required, not only in terms of fate of the extra carbon, but also the knock-on effects such as oxygen depletion, nitrous oxide (a greenhouse gas) production, and loss of nutrients in waters that support production in other regions. “ Observation and verification of these impacts represent huge technological challenges which will require significant financial investment to support major operations. Until this is achieved and the knock-on effects proven to be minor compared to the benefits of iron-induced carbon sequestration, then iron fertilisation cannot be considered as a viable geoengineering approach.” Professor Philip Boyd at Otago University’s NIWA Centre for Chemical and Physical Oceanography (also a PM’s Science Price Recipient), comments: “It’s ‘location, location, location’. “Not all blooms are made equal…This bloom is an end-member where conditions permitted a very efficient export of material to the deep ocean. “Other blooms export much less material – such as our SERIES bloom that CLiff Law and I led in the NE Pacific in early 2000′s. “I don’t think this changes anything in this geoengineering debate. “What we need to better understand is what controls the export efficiency of different blooms”. Prof Tom Trull, Professor of Marine Biogeochemistry at CSIRO Marine and Atmospheric Research and the University of Tasmania, and leader of the Carbon Program at Australia’s Antarctic Climate and Ecosystems Cooperative Research Centre, comments: “Carbon sequestration can be achieved by enhanced C export or its penetration further into the deep sea, or both. EIFEX did not demonstrate enhanced surface carbon exort beyond what would occur naturally anyway, because the Fe fertilisation stimulated diatoms which require silicon, and that element is naturally depleted anyway as upwelled Southern Ocean surface water spread northward. But EIFEX did observe surprisingly deep C export. It remains to be seen whether this was an outcome particular to the EIFEX location and timing. Larger polar experiments as proposed by the authors will be important to examine this, as well as attempt to push beyond the Si limitation boundary and stimulate export from communities which do not require silicon.” “The current IMO and UNCBD moratoriums on iron fertilisations for purposes other than research are motivated by concerns about environmental impacts. EIFEX did not seek to test these concerns and thus cannot be cited as a reason to re-evaluate them. This is a difficult issue in that no iron fertilisations have produced deleterious environmental effects, but proof that risks are minimal is far from being demonstrated. Continued experimentation with greater inclusion of impact assessment remains the wisest course.” Our colleagues at the UK Science Media Centre also collected the following commentary: Prof Andy Ridgwell, Professor in Earth System Modelling at the University of Bristol: “The authors have obtained direct evidence for efficient and rapid carbon export to the deep ocean when stimulating phytoplankton growth with the nutrient iron. “This is an extremely interesting result and one that is sure not only to renew interest in the potential for deliberate (iron) fertilisation for sequestering fossil fuel CO2 in the future – a geoengineering proposal not only currently banned under international regulations and previously assumed to be an inefficient way of sequestering carbon – but also in the understanding of past climates. “Exactly why atmospheric CO2 concentrations during the last glacial were approximately one third lower than the current interglacial average is still hotly debated. “The results of this study hint at a greater importance for higher glacial dust (and iron) fluxes to the surface ocean in strengthening the ocean carbon pump and hence in lowering atmospheric CO2.” Dr Michael Steinke, Lecturer in Marine Sciences at the University of Essex, said: “This article … provides the very first evidence of a man-made conduit between the increasingly CO2-burdened atmosphere and the deep sea. This transfer of CO2 assists with cooling our climate and keeping temperature at a level to facilitate life on our planet. “The group … managed to add 7000kg of iron fertilizer to just the right part of the Antarctic Ocean to stimulate phytoplankton growth, increase the uptake of CO2 from the atmosphere and, crucially, demonstrate that at least half of this material disappeared into the deep sea. “Several other scientific experiments tried this before but the oceanographic conditions were such that the CO2 from the decay of phytoplankton was transferred straight back into the atmosphere so that no additional cooling was produced from fertilising the sea. “Will this open up the gates to large-scale geoengineering using ocean fertilisation to mitigate climate change? Likely not, since the logistics of finding the right spot for such experiments are difficult and costly! Of the twelve fertilisation experiments of this kind carried out since 1993, many showed the desired increase in CO2 drawdown from the atmosphere but this group’s experiment is the only example to date that demonstrates the all-important carbon burial in the deep sea sediments, away from the atmosphere.” Dr Dave Reay, senior lecturer in carbon management at the University of Edinburgh: “If the 50% figure for algal bloom biomass sinking to the deep ocean is correct then this represents a whole new ball game in terms of iron fertilisation as a geoengineering technique. “Maybe such deliberate enhancement of carbon storage in the oceans has more legs than we thought but, as the authors acknowledge, it’s still far too early to run with it.”

### Aff- Impact Turn- Algal blooms

#### Ocean fertilization bad- results in dead zones, kills bio-d, and increases algal blooms. And be skeptical of their solvency claims- there is a reason we haven’t tried geo-engineering yet

UNEP 11 (United Nations Environment Program, May 2011, “Geoengineering to Combat Global Warming”, http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article\_id=52)//JM

Box 2: Ocean fertilization with iron The idea of fertilizing the ocean with iron or other nutrients stems from the understanding that microscopic marine plants absorb CO2 through photosynthesis. As these plants sink deeper in the water column, they take CO2 from the surface and release it further below. Over thousands of years, most of the CO2 currently being released to the atmosphere will be transferred to the deep sea. The limiting factor in this system is the supply of nutrients available for net algal growth at the ocean’s surface (The Royal Society 2009). Thus, ocean fertilization is a geoengineering proposal that involves introducing nutrients to the ocean’s surface to activate algal growth (Wallace and others 2010). The Royal Society notes that the effects of iron fertilization have been studied in a series of about 12 small-scale test releases over the past 15 years, over areas of about 10 km2. They resulted in predicted algal blooms, but other limiting factors, such as respiration or grazing by zooplankton, moderated the impacts. It found that the increased algal blooms from injecting iron in the ocean would absorb relatively little carbon and would consume enormous amounts of oxygen, potentially causing oceanic "dead zones." It pointed out other potential dangerous side effects, such as suppressing Asian monsoons or modifying the oceans' acidity (The Royal Society 2009). Another recent assessment looked specifically at ocean fertilization. In 2010, the Intergovernmental Oceanographic Commission (IOC), which is part of UNESCO, published a timely overview of the scientific understanding of ocean fertilization. The report, based on a review of the published literature and extensive consultations involving independent scientists from seven countries, is aimed at policy makers. It noted that the small-scale and short-term nature of ocean fertilization research prevented the acquisition of knowledge about the impacts of iron fertilization on zooplankton, fish and seafloor biota, and measures of the magnitude of carbon export to the deep ocean. The IOC's most salient finding is that even over one-hundred years, very large-scale fertilization would remove only modest amounts of CO2 from the atmosphere. Recent models have calculated the cumulative amount of CO2 sequestered in a massive fertilization scenario over 100 years. It is in the range of 25-75 Gt (gigatonnes) of carbon. By comparison, in a business-as-usual scenario of fossil-fuel burning for the same period, the cumulative emissions would be about 1 500 Gt of carbon (Wallace and others 2010). The IOC report also noted the dearth of information on the effects of fertilizing low nutrient regions and that there have been no experimental studies at the geographical and temporal scales necessary to understand the potential for commercial applications. It cautioned that monitoring is essential to assess the total benefits and impacts but that they would be very difficult and costly to investigate (Wallace and others 2010). The potential climate change mitigation capacity and the short and long-terms risks to humans and ecosystems and their distribution over the planet and among groups of people are different for each geoengineering proposal. For example, although direct CO2 removal would have global benefits, there would be local impacts; and while reflecting sunlight would reduce the Earth's temperature, it could also adversely affect climate and weather patterns as well as change ecosystem structure and functions, and its impacts would not be the same for all nations and peoples (AMS 2009). The implications of most geoengineering schemes are enormous and include unknown risks and unintended side effects; probable irreversibility; wide-spread impacts on globally shared resources affecting people who may disagree with the actions; and the potential for one group of people to benefit at the expense of another (Williamson 2011). Thus, there are many legal, ethical, diplomatic and security concerns to overcome before these schemes can be considered solutions.

And algal blooms will drain atmospheric oxygen until everything dies

ScienceDaily 08, (Website based on providing objective science, April 7, “Harmful Algae Takes Advantage Of Global Warming: More Algae Blooms Expected”, <http://www.sciencedaily.com/releases/2008/04/080403140928.htm>l)

Fish and other aquatic animals and plants stand little chance against cyanobacteria. The algae crowds the surface water, shading out plants -- fish food -- below. The fish generally avoid cyanobacteria, so they're left without food. And when the algae die they sink to the bottom where their decomposition can lead to extensive depletion of oxygen. These cyanobacteria -- blue-green algae -- were the first plants on earth to produce oxygen. "It's ironic," Paerl said. "Without cyanobacteria, we wouldn't be here. Animal life needed the oxygen the algae produced." Now, however, it threatens the health and livelihood of people who depend on infested waters for drinking water or income from fishing and recreational use. These algae that were first on the scene, Paerl predicts, will be the last to go ... right after the cockroaches.

Decline causes extinction

Tatchell 8- (Peter Tatchell, Columnist for The Guardian, August 13, “The oxygen crisis”, The Guardian,

<http://www.guardian.co.uk/commentisfree/2008/aug/13/carbonemissions.climatechange>)

Compared to prehistoric times, the level of oxygen in the earth's atmosphere has declined by over a third and in polluted cities the decline may be more than 50%. This change in the makeup of the air we breathe has potentially serious implications for our health. Indeed, it could ultimately threaten the survival of human life on earth, according to Roddy Newman, who is drafting a new book, The Oxygen Crisis. I am not a scientist, but this seems a reasonable concern. It is a possibility that we should examine and assess. So, what's the evidence? Around 10,000 years ago, the planet's [forest cover](http://www.unep.org/geo/GDOutlook/) was at least twice what it is today, which means that forests are now emitting only half the amount of oxygen. Desertification and deforestation are rapidly accelerating this long-term loss of oxygen sources. The story at sea is much the same. Nasa reports that in the north Pacific ocean oxygen-producing [phytoplankton concentrations](http://www.gsfc.nasa.gov/topstory/20020801plankton.html) are 30% lower today, compared to the 1980s. This is a huge drop in just three decades. Moreover, the UN environment programme confirmed in 2004 that there were nearly 150 "[dead zones](http://www.msnbc.msn.com/id/4624359/)" in the world's oceans where discharged sewage and industrial waste, farm fertiliser run-off and other pollutants have reduced oxygen levels to such an extent that most or all sea creatures can no longer live there. This oxygen starvation is reducing regional fish stocks and diminishing the food supplies of populations that are dependent on fishing. It also causes genetic mutations and hormonal changes that can affect the reproductive capacity of sea life, which could further diminish global fish supplies. Professor [Robert Berner](http://earth.geology.yale.edu/~berner/) of Yale University has researched oxygen levels in prehistoric times by chemically analysing air bubbles trapped in fossilised tree amber. He suggests that humans breathed a much more oxygen-rich air 10,000 years ago. Further back, the oxygen levels were even greater. [Robert Sloan](http://www.geo.umn.edu/people/profs/SLOAN.html) has listed the percentage of oxygen in samples of dinosaur-era amber as: 28% (130m years ago), 29% (115m years ago), 35% (95m years ago), 33% (88m years ago), 35% (75m years ago), 35% (70m years ago), 35% (68m years ago), 31% (65.2m years ago), and 29% (65m years ago). Professor [Ian Plimer](http://www.expertguide.com.au/!ProfessorIanPlimer!_7859.aspx) of Adelaide University and Professor [Jon Harrison](http://sols.asu.edu/faculty/jharrison.php) of the University of Arizona concur. Like most other scientists they accept that oxygen levels in the atmosphere in prehistoric times averaged around 30% to 35%, compared to only 21% today – and that the levels are even less in densely populated, polluted city centres and industrial complexes, perhaps only 15 % or lower. Much of this recent, accelerated change is down to human activity, notably the industrial revolution and the burning of fossil fuels. The Professor of Geological Sciences at Notre Dame University in Indiana, [J Keith Rigby](http://www.nd.edu/~cegeos/people/faculty/rigby.htm), was quoted in 1993-1994 as saying: “In the 20th century, humanity has pumped increasing amounts of carbon dioxide into the atmosphere by burning the carbon stored in coal, petroleum and natural gas. In the process, we've also been consuming oxygen and destroying plant life – cutting down forests at an alarming rate and thereby short-circuiting the cycle's natural rebound. We're artificially slowing down one process and speeding up another, forcing a change in the atmosphere.”

### Aff- Impact turn- Bio-d

#### Ocean fertilization bad- results in dead zones, kills bio-d, and increases algal blooms. And be skeptical of their solvency claims- there is a reason we haven’t tried geo-engineering yet

UNEP 11 (United Nations Environment Program, May 2011, “Geoengineering to Combat Global Warming”, http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article\_id=52)//JM

Box 2: Ocean fertilization with iron The idea of fertilizing the ocean with iron or other nutrients stems from the understanding that microscopic marine plants absorb CO2 through photosynthesis. As these plants sink deeper in the water column, they take CO2 from the surface and release it further below. Over thousands of years, most of the CO2 currently being released to the atmosphere will be transferred to the deep sea. The limiting factor in this system is the supply of nutrients available for net algal growth at the ocean’s surface (The Royal Society 2009). Thus, ocean fertilization is a geoengineering proposal that involves introducing nutrients to the ocean’s surface to activate algal growth (Wallace and others 2010). The Royal Society notes that the effects of iron fertilization have been studied in a series of about 12 small-scale test releases over the past 15 years, over areas of about 10 km2. They resulted in predicted algal blooms, but other limiting factors, such as respiration or grazing by zooplankton, moderated the impacts. It found that the increased algal blooms from injecting iron in the ocean would absorb relatively little carbon and would consume enormous amounts of oxygen, potentially causing oceanic "dead zones." It pointed out other potential dangerous side effects, such as suppressing Asian monsoons or modifying the oceans' acidity (The Royal Society 2009). Another recent assessment looked specifically at ocean fertilization. In 2010, the Intergovernmental Oceanographic Commission (IOC), which is part of UNESCO, published a timely overview of the scientific understanding of ocean fertilization. The report, based on a review of the published literature and extensive consultations involving independent scientists from seven countries, is aimed at policy makers. It noted that the small-scale and short-term nature of ocean fertilization research prevented the acquisition of knowledge about the impacts of iron fertilization on zooplankton, fish and seafloor biota, and measures of the magnitude of carbon export to the deep ocean. The IOC's most salient finding is that even over one-hundred years, very large-scale fertilization would remove only modest amounts of CO2 from the atmosphere. Recent models have calculated the cumulative amount of CO2 sequestered in a massive fertilization scenario over 100 years. It is in the range of 25-75 Gt (gigatonnes) of carbon. By comparison, in a business-as-usual scenario of fossil-fuel burning for the same period, the cumulative emissions would be about 1 500 Gt of carbon (Wallace and others 2010). The IOC report also noted the dearth of information on the effects of fertilizing low nutrient regions and that there have been no experimental studies at the geographical and temporal scales necessary to understand the potential for commercial applications. It cautioned that monitoring is essential to assess the total benefits and impacts but that they would be very difficult and costly to investigate (Wallace and others 2010). The potential climate change mitigation capacity and the short and long-terms risks to humans and ecosystems and their distribution over the planet and among groups of people are different for each geoengineering proposal. For example, although direct CO2 removal would have global benefits, there would be local impacts; and while reflecting sunlight would reduce the Earth's temperature, it could also adversely affect climate and weather patterns as well as change ecosystem structure and functions, and its impacts would not be the same for all nations and peoples (AMS 2009). The implications of most geoengineering schemes are enormous and include unknown risks and unintended side effects; probable irreversibility; wide-spread impacts on globally shared resources affecting people who may disagree with the actions; and the potential for one group of people to benefit at the expense of another (Williamson 2011). Thus, there are many legal, ethical, diplomatic and security concerns to overcome before these schemes can be considered solutions.

#### Ocean biodiversity loss causes extinction

Craig, 3 (Robin Kundis Craig, Associate Professor of Law at the Indiana University School of Law, 2003, “Taking Steps Toward Marine Wilderness Protection? Fishing and Coral Reef Marine Reserves in Florida and Hawaii,” http://papers.ssrn.com/sol3/papers.cfm?abstract\_id=1289250)

Biodiversity and ecosystem function arguments for conserving marine ecosystems also exist, just as they do for terrestrial ecosystems, but these arguments have thus far rarely been raised in political debates. For example, besides significant tourism values - the most economically valuable ecosystem service coral reefs provide, worldwide - coral reefs protect against storms and dampen other environmental fluctuations, services worth more than ten times the reefs' value for food production. n856 Waste treatment is another significant, non-extractive ecosystem function that intact coral reef ecosystems provide. n857 More generally, "ocean ecosystems play a major role in the global geochemical cycling of all the elements that represent the basic building blocks of living organisms, carbon, nitrogen, oxygen, phosphorus, and sulfur, as well as other less abundant but necessary elements." n858 In a very real and direct sense, therefore, human degradation of marine ecosystems impairs the planet's ability to support life. Maintaining biodiversity is often critical to maintaining the functions of marine ecosystems. Current evidence shows that, in general, an ecosystem's ability to keep functioning in the face of disturbance is strongly dependent on its biodiversity, "indicating that more diverse ecosystems are more stable." n859 Coral reef ecosystems are particularly dependent on their biodiversity. [\*265] Most ecologists agree that the complexity of interactions and degree of interrelatedness among component species is higher on coral reefs than in any other marine environment. This implies that the ecosystem functioning that produces the most highly valued components is also complex and that many otherwise insignificant species have strong effects on sustaining the rest of the reef system. n860 Thus, maintaining and restoring the biodiversity of marine ecosystems is critical to maintaining and restoring the ecosystem services that they provide. Non-use biodiversity values for marine ecosystems have been calculated in the wake of marine disasters, like the Exxon Valdez oil spill in Alaska. n861 Similar calculations could derive preservation values for marine wilderness. However, economic value, or economic value equivalents, should not be "the sole or even primary justification for conservation of ocean ecosystems. Ethical arguments also have considerable force and merit." n862 At the forefront of such arguments should be a recognition of how little we know about the sea - and about the actual effect of human activities on marine ecosystems. The United States has traditionally failed to protect marine ecosystems because it was difficult to detect anthropogenic harm to the oceans, but we now know that such harm is occurring - even though we are not completely sure about causation or about how to fix every problem. Ecosystems like the NWHI coral reef ecosystem should inspire lawmakers and policymakers to admit that most of the time we really do not know what we are doing to the sea and hence should be preserving marine wilderness whenever we can - especially when the United States has within its territory relatively pristine marine ecosystems that may be unique in the world. We may not know much about the sea, but we do know this much: if we kill the ocean we kill ourselves, and we will take most of the biosphere with us. The Black Sea is almost dead, n863 its once-complex and productive ecosystem almost entirely replaced by a monoculture of comb jellies, "starving out fish and dolphins, emptying fishermen's nets, and converting the web of life into brainless, wraith-like blobs of jelly." n864 More importantly, the Black Sea is not necessarily unique.

### Aff- Impact Turn- Dead zones

#### Ocean fertilization bad- results in dead zones, kills bio-d, and increases algal blooms. And be skeptical of their solvency claims- there is a reason we haven’t tried geo-engineering yet

UNEP 11 (United Nations Environment Program, May 2011, “Geoengineering to Combat Global Warming”, http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article\_id=52)//JM

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#### Dead zones result in extinction- four of the past five mass extinctions prove- and we have a unique brink to our impact

ABC 10 (Australian Broadcasting Company, November 30 2010, “Extinctions feared as ocean dead zones grow”, http://www.cbc.ca/news/technology/story/2010/11/30/mass-extinction-dead-zone.html)//JM

Scientists fear the planet is on the brink of another mass extinction as ocean dead zones continue to grow in size and number. More than 400 ocean dead zones — areas so low in oxygen that sea life cannot survive — have been reported by oceanographers around the world between 2000 and 2008. That is compared with 300 in the 1990s and 120 in the 1980s. Ove Hoegh-Guldberg, a professor at the ARC Centre of Excellence for Coral Reef Studies (CoECRS) and the University of Queensland in Australia, says there is growing evidence that declining oxygen levels in the ocean have played a major role in at least four of the planet's five mass extinctions. "Until recently the best hypothesis for them was a meteor strike," he said. "So 65 million years ago they've got very good evidence ... all the dinosaurs died because of smoke and stuff in the atmosphere from a meteor strike. "But with the four other mass extinction events, one of the best explanations now is that these periods were preceded by an increase of volcanic activity, and that volcanic activity caused a change in ocean circulation. "Just as we are seeing at a smaller scale today, huge parts of the ocean became anoxic at depth. "The consequence of that is that you had increased amounts of rotten egg gas, hydrogen sulfide, going up into the atmosphere, and that is thought to be what may have caused some of these other extinction events." Hoegh-Guldberg says up to 90 per cent of life has perished in previous mass extinctions and that a similar loss of life could occur in the next 100 years. "We're already having another mass extinction due to humans wiping out life and so on, but it looks like it could get as high as those previous events," he said. "So it's the combination of this alteration to coastlines, climate change and everything, that has a lot of us worried we are going to drive the sixth extinction event and it will happen over the next 100 years because we are interfering with the things that keep species alive." Hearts and lungs Scientists say ocean dead zones, which vary in size from one square kilometre to 70,000 square kilometres, have been found all over the world. Particular hotspots include the Gulf of Mexico, off Namibia in the South Atlantic, in the Bay of Bengal, in the Baltic, the Black Sea, the tropical South Pacific, off China and southeastern Australia. "We're seeing an expansion of areas of the ocean which are very low in oxygen and also very low in nutrients," Hoegh-Guldberg said. "Climate change is driving changes to water circulation — so winds, strange weather patterns, have a consequence for how the ocean turns over and aerates and so on, and it's the winds which are delivering a lot of organic compounds into the deep sea. "At the same time we are putting a lot of fertilizer off coastlines, those sorts of things are incubating these deep water anoxic zones. "So it's the combination of those two things that are having a big change on how the ocean works." He said organic matter building up in the sea is a huge problem. "You get enormous amounts of organic carbon building up at depth, bacteria then likes to break down that organic matter and bacteria uses up the oxygen," he said. "So then what you get is a substantial drop in oxygen — that then has the consequences for fishers, for the productivity of coastlines and so on." Destructive path Mark McCormick, an associate professor at CoECRS and James Cook University, said low oxygen levels increase stress on fish. "We know from our recent work that increases in stress result in deformities, leading to poorer survival of fish larvae," he said. "It has also been found they can cause fish to have smaller ovaries, produce fewer eggs, so larvae are also smaller and less likely to survive." Hoegh-Guldberg said while the dead zones may only exist in pockets of ocean today, it will affect a far greater area in the future unless steps are taken to reduce the impact of human activities on the world's oceans and their life.

### Aff Dead Zones Impact- Ozone

#### Dead zones lead to holes in the ozone and increased warming

ScienceDaily 10 (Website based on providing objective science, March 12 2010, “Aquatic 'Dead Zones' Contributing to Climate Change”, http://www.sciencedaily.com/releases/2010/03/100311141213.htm)//JM

The increased frequency and intensity of oxygen-deprived "dead zones" along the world's coasts can negatively impact environmental conditions in far more than just local waters. In the March 12 edition of the journal Science, University of Maryland Center for Environmental Science oceanographer Dr. Lou Codispoti explains that the increased amount of nitrous oxide (N2O) produced in low-oxygen (hypoxic) waters can elevate concentrations in the atmosphere, further exacerbating the impacts of global warming and contributing to ozone "holes" that cause an increase in our exposure to harmful UV radiation. As the volume of hypoxic waters move towards the sea surface and expands along our coasts, their ability to produce the greenhouse gas nitrous oxide increases," explains Dr. Codispoti of the UMCES Horn Point Laboratory. "With low-oxygen waters currently producing about half of the ocean's net nitrous oxide, we could see an additional significant atmospheric increase if these 'dead zones' continue to expand." Although present in minute concentrations in Earth's atmosphere, nitrous oxide is a highly potent greenhouse gas and is becoming a key factor in stratospheric ozone destruction. For the past 400,000 years, changes in atmospheric N2O appear to have roughly paralleled changes in carbon dioxide CO2 and have had modest impacts on climate, but this may change. Just as human activities may be causing an unprecedented rise in the terrestrial N2O sources, marine N2O production may also rise substantially as a result of nutrient pollution, warming waters and ocean acidification. Because the marine environment is a net producer of N2O, much of this production will be lost to the atmosphere, thus further intensifying its climatic impact.

#### Extinction

Smith and Daniel, 99—(Tyrrel W. Smith, Jr., Ph.D. TRW Space & Electronics Group and John R. Edwards Daniel Pilson Environmental Management Branch “Summary of the Impact of Launch Vehicle Exhaust and Deorbiting Space and Meteorite Debris on Stratospheric Ozone” <http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA414306>)

The ozone layer is critical to life on Earth because it absorbs biologically damaging solar ultraviolet radiation. The amount of solar UV radiation received at any particular location on the Earth’s surface depends upon the position of the Sun above the horizon, the amount of ozone in the atmosphere, and local cloudiness and pollution. Scientists agree that, in the absence of changes in clouds or pollution, decreases in atmospheric ozone lead to increases in ground-level UV radiation (Martin [1998], WMO [1998]). Prior to the late 1980s, instruments with the necessary accuracy and stability for measurement of small long-term trends in ground-level UV-B were not available. Therefore, the data from urban locations with older, less-specialized instruments provide much less reliable information, especially since simultaneous measurements of changes in cloudiness or local pollution are not available. When high-quality measurements were made in other areas far from major cities and their associated air pollution, decreases in ozone have regularly been accompanied by increases in UV-B (WMO [1998]). Therefore, this increase in ultraviolet radiation received at the Earth's surface would likely increase the incidence of skin cancer and melanoma, as well as possibly impairing the human immune system (Kerr et al., [1993]). Damage to terrestrial and aquatic ecosystems also may occur (Martin [1998], WMO [1998]).

#### Ozone depletion contributes to ocean acidification

Jacquot ‘08(Jeremy Elton Jacquot 12/12/2008 Treehugger <http://www.treehugger.com/clean-technology/ozone-depletion-contributes-to-ocean-acidification-in-the-southern-ocean.html>)

**Forty percent: That is the share of annual oceanic carbon dioxide uptake accounted for by the Southern Ocean**. Given that oceans comprise Earth's largest carbon sink, that is not an insignificant figure; indeed, **this sole region is responsible for absorbing a staggering amount of anthropogenic emissions** -- close to 1 petagram (1 Pg = 1,000,000,000,000,000 grams) per year. **Which makes it all the more worrisome that ocean acidification is** [rapidly weakening its capacity to take up our excess emissions](http://www.treehugger.com/files/2008/11/southern-ocean-acidification.php)**,** something I discussed last month. Now we hear that o**zone depletion, already a long-standing problem in itself, could be worsening the situation**. [*Nature*'s Anna Barnett](http://www.nature.com/news/2008/081209/full/news.2008.1292.html) (sub. required) **reports** on the findings of new research **linking the hole in the ozone layer over Antarctica to a deterioration of the Southern Ocean's buffering capacity.** According to Andrew Lenton, a marine biochemist at the Pierre and Marie Curie University in Paris, **ozone damage and the associated climatic effects of rising GHG emissions are strengthening winds in the region, intensifying the Southern Ocean's upwelling system (the movement of cold, nutrient-rich deep waters to the surface).** Though **upwelling** stimulates primary productivity by making more nutrients available to phytoplankton, it also **has the** nasty **tendency of** causing more carbon dioxide "outgassing" -- basically, **letting more CO2 escape to the atmospher**e. Lenton and his colleagues built several simulations that coupled the ozone hole's effects on winds to currents and dissolved carbon levels. **Comparing the results of simulations run both with and without ozone depletion since 1975**, Lenton found that **the presence of the ozone hole helped explain the weakening of the Southern Ocean's buffering capacity; from 1994 to 2004, it contributed to a drop in surface seawater pH** of 0.01 units, which is worse than it sounds (this seemingly infinitesimal drop represents one-tenth of the change in seawater pH since pre-industrial times).

#### Acidification results in extinction

Sify 2010 – Sydney newspaper citing Ove Hoegh-Guldberg, professor at University of Queensland and Director of the Global Change Institute, and John Bruno, associate professor of Marine Science at UNC (Sify News, “Could unbridled climate changes lead to human extinction?”, <http://www.sify.com/news/could-unbridled-climate-changes-lead-to-human-extinction-news-international-kgtrOhdaahc.html>

The findings of the comprehensive report: **'The impact of climate change** on the world's marine ecosystems' **emerged from a synthesis of recent research on the world's oceans, carried out by two of the world's leading marine scientists**. One of the authors of the report is Ove Hoegh-Guldberg, professor at The University of Queensland and the director of its Global Change Institute (GCI). **'We may see sudden, unexpected changes that have serious ramifications** for the overall well-being of humans, **including the capacity of the planet to support people.** This is further **evidence that we are well on the way to** the next great **extinction** event,' says Hoegh-Guldberg. 'The findings have enormous implications for mankind, particularly **if the trend continues. The** earth's **ocean, which produces half of the oxygen we breathe and absorbs 30 per cent of human-generated carbon dioxide,** is equivalent to its heart and lungs. This study **shows** worrying **signs of ill-health**. It's as if the earth has been smoking two packs of cigarettes a day!,' he added. 'We are entering a period in which the ocean services upon which humanity depends are undergoing massive change and in some cases beginning to fail', he added. The 'fundamental and comprehensive' **changes** to marine life identified in the report **include rapidly warming and acidifying oceans, changes in water circulation and expansion of dead zones** within the ocean depths. These are driving major changes in marine ecosystems: **less** abundant coral **reefs**, sea grasses and **mangroves** (important **fish** nurseries); fewer, smaller fish; a **breakdown in food chains**; changes in the distribution of marine life; **and more** frequent **diseases and pests** among marine organisms. Study co-author John F Bruno, associate professor in marine science at The University of North Carolina, says **greenhouse gas emissions are modifying many physical and geochemical aspects** of the planet's oceans, **in ways 'unprecedented** in nearly a million years'. 'This is causing fundamental and comprehensive changes to the way marine ecosystems function,' Bruno warned, according to a GCI release. These findings were published in Science

# \*\*\*New Impact Scenarios\*\*\*

## ---Bio-D---

### Biodiversity- Pika

#### Warming causes Pika extinction

Berwyn 7/23 (Bob Berwyn- staff writer for Summit Voice, July 23 2012, “Global warming: New evidence of Great Basin pika decline”, http://summitcountyvoice.com/2012/07/23/global-warming-new-evidence-of-great-basin-pika-decline/)//JM

SUMMIT COUNTY —Some of North America’s most vulnerable mammals are definitely feeling the heat of global warming, as localized pika extinctions in the Great Basin have increased at five times the 20th century average in the last 10 years. Pikas have long been considered sentinels of climate change impacts because they are sensitive to small changes in climate and are often exposed to frequent swings in temperature and wind speed, poorly developed soils and generally harsher conditions than animals living at lower elevations. American pikas are small, mountain-dwelling mammals that lives in rocky talus slopes and lava flows typically found in mountain ecosystems throughout the western United States. A recent Colorado study found that pikas are holding their own in the southern Rockies, at least for now, but the pika habitat in the Great Basin is much more constrained by elevation and vegetation. The Great Basin study also found that the lowest elevation that pikas are occupying moved upslope 11 times faster during the past decade than during the 20th century, suggesting that their habitat is now shrinking rapidly.

#### Pika’s are a keystone species

ASU 11 (Arizona State University School of Life Science, 2011, “Scientist ponders disappearing species in ´Year of the Rabbit´”, http://sols.asu.edu/news/2011/06\_news\_11.php)//JM

Smith’s favorite study animal, the plateau pika, Ochotona curzoniae, is also a keystone species. Pika burrows on the Tibetan Plateau provide habitats for other rare and geographically-restricted species. Hume’s ground pecker, Pseudopodoces humilis, and at least five species of snow finch depend on pika burrows, as do some species of lizard. Similarly, plateau pikas are an integral prey species for several species of weasel, fox, wolf, the ‘Near Threatened’ Pallas’s cat,Otocolobus manul, and the brown bear, Ursus arctos. More importantly, pika burrowing activities contribute to soil turnover and enrichment, which leads to increased plant species richness in areas they inhabit. This soil turnover also promotes nutrient cycling in the soil, and decreases the potential for erosion during heavy monsoons. In spite of the benefits to the environment, pikas have, like prairie dogs, been the target of extensive and long-lasting poisoning campaigns.

#### Keystone species loss leads to extinction- can’t predict the possible chain reactions

Wapner 94 (Paul Wapner- American University Department of International Politics and Foreign Policy, August 1994, "On the Global Dimension of Environmental Challenges." Politics and the Life Sciences, pg. 177)

Massive extinction of species is dangerous, then, because one cannot predict which species are expendable to the system as a whole. As Philip Hoose remarks, "Plants and animals cannot tell us what they mean to each other." One can never be sure which species holds up fundamental biological relationships in the planetary ecosystem. And, because removing species is an irreversible act, it may be too late to save the system after the extinction of key plants or animals. According to the U.S. National Research Council, "The ramifications of an ecological change of this magnitude [vast extinction of species] are so far reaching that no one on earth will escape them." Trifling with the "lives" of species is like playing Russian roulette, with our collective future as the stakes.

## ---Debris---

### Debris- Economy

#### CO2 increases risk of satellite-debris collisions- prefer this study- it was the first to take into account atmospheric conditions

Cheng 6 (Alicia Cheng- AP and USA today science writer, December 12 2012, “CO2 Could Extend the Life of Space Junk”, http://www.usatoday.com/tech/science/space/2006-12-12-space-junk-co2\_x.htm)//JM

Carbon dioxide emissions from global warming are cooling and shrinking the outermost atmosphere, keeping orbiting spacecraft airborne longer but also increasing the threat that space junk poses to satellites, scientists reported Monday. In a signal of the wide-ranging impacts of climate change, the thinning of the thermosphere, which begins about 60 miles above Earth and extends up to 400 miles, reduces the drag on orbiting spacecraft but also extends the lifespan of space junk — leftovers from space missions, old satellites, items astronauts lose during spacewalks and the like. "It's a bit of a two-edged sword," said Stanley Solomon, a senior scientist at the National Center for Atmospheric Research, who presented the new results at an American Geophysical Union meeting in San Francisco. Using a computer model, Solomon and his colleagues estimated that the air density of the outer atmosphere declined about 5% over the past three decades and could decrease 40% by the end of the century. Knowledge of how the outer atmosphere responds to carbon dioxide levels could help NASA and international space agencies time their spacecraft launches and calculate their fuel needs. Solomon said that a less dense outer atmosphere should not affect launches in the near term, but that it could be problematic in the future with the increase of space litter. "In the long haul, it means we have to be even more assiduous about not letting miscellaneous pieces of metal float around," Solomon said. Researchers have long predicted that carbon dioxide, produced when fossil fuels such as oil and natural gas are burned, would cool the outer atmosphere. Solomon's conclusions mirror previous research that predicted similar effects, including recent observations that measured the drag of satellites over time. Robert Dickinson, a pioneer in the field and a professor of earth and atmospheric sciences at the Georgia Institute of Technology, said the latest work is unique because it looks at the effects of solar activity on the atmosphere. An active solar cycle could spawn magnetic storms that will be more severe and disruptive to communication systems.

#### Space debris collapses the global economy

Ansdell 10 (Megan Ansdell, Grad Student @ George Washington University’s Elliot School of Int’l Affairs, where she focused on space policy. “Active Space Debris Removal: Needs, Implications, and Recommendations for Today’s Geopolitical Environment,” www.princeton.edu/jpia/past-issues-1/2010/Space-Debris-Removal.pdf)

**There are** currently **hundreds of millions of space debris fragments orbiting** the Earth **at** speeds of up to **several kilometers per second**. Although the majority of these fragments result from the space activities of only three countries—China, Russia, and the United States—the indiscriminate nature of orbital mechanics means that **they pose a** continuous threat **to** all assets **in Earth’s orbit. There are now roughly 300,000 pieces of space debris large enough to completely destroy operating satellites upon impact** (Wright 2007, 36; Johnson 2009a, 1). It is likely that space debris will become a significant problem within the next several decades. Predictive studies **show that** if humans do not take action to control the space debris population, an increasing number of unintentional collisions between orbiting objects will lead to the runaway growth of space debris in Earth’s orbit (Liou and Johnson 2006). This uncontrolled growth of space debris threatens **the ability of satellites to deliver** the **services** humanity has come to rely on in its day-to-day activities. For example, Global Positioning System (GPS) precision timing and navigation signals are a significant component of the modern global economy; a GPS **failure could** disrupt emergency response services, cripple global banking systems, **and** interrupt electric power grids (Logsdon 2001).

#### Economic decline triggers nuclear war

Harris and Burrows 9 (Mathew, PhD European History at Cambridge, counselor in the National Intelligence Council (NIC) and Jennifer, member of the NIC’s Long Range Analysis Unit “Revisiting the Future: Geopolitical Effects of the Financial Crisis” <http://www.ciaonet.org/journals/twq/v32i2/f_0016178_13952.pdf>, AM)

Increased Potential for Global Conflict Of course, the report encompasses more than economics and indeed believes the future is likely to be the result of a number of intersecting and interlocking forces. With so many possible permutations of outcomes, each with ample Revisiting the Future opportunity for unintended consequences, there is a growing sense of insecurity. Even so, history may be more instructive than ever. While we continue to believe that the Great Depression is not likely to be repeated, the lessons to be drawn from that period include the harmful effects on fledgling democracies and multiethnic societies (think Central Europe in 1920s and 1930s) and on the sustainability of multilateral institutions (think League of Nations in the same period). There is no reason to think that this would not be true in the twenty-first as much as in the twentieth century. For that reason, the ways in which the potential for greater conflict could grow would seem to be even more apt in a constantly volatile economic environment as they would be if change would be steadier. In surveying those risks, the report stressed the likelihood that terrorism and nonproliferation will remain priorities even as resource issues move up on the international agenda. Terrorism’s appeal will decline if economic growth continues in the Middle East and youth unemployment is reduced. For those terrorist groups that remain active in 2025, however, the diffusion of technologies and scientific knowledge will place some of the world’s most dangerous capabilities within their reach. Terrorist groups in 2025 will likely be a combination of descendants of long established groups\_inheriting organizational structures, command and control processes, and training procedures necessary to conduct sophisticated attacks\_and newly emergent collections of the angry and disenfranchised that become self-radicalized, particularly in the absence of economic outlets that would become narrower in an economic downturn. The most dangerous casualty of any economically-induced drawdown of U.S. military presence would almost certainly be the Middle East. Although Iran’s acquisition of nuclear weapons is not inevitable, worries about a nuclear-armed Iran could lead states in the region to develop new security arrangements with external powers, acquire additional weapons, and consider pursuing their own nuclear ambitions**.** It is not clear that the type of stable deterrent relationship that existed between the great powers for most of the Cold War would emerge naturally in the Middle East with a nuclear Iran. Episodes of low intensity conflict and terrorism taking place under a nuclear umbrella could lead to an unintended escalation and broader conflict if clear red lines between those states involved are not well established. The close proximity of potential nuclear rivals combined with underdeveloped surveillance capabilities and mobile dual-capable Iranian missile systems also will produce inherent difficulties **in achieving reliable indications and warning of an impending nuclear attack**. The lack of strategic depth in neighboring states like Israel, short warning and missile flight times, and uncertainty of Iranian intentions may place more focus on preemption rather than defense, potentially leading to escalating crises. 36 Types of conflict that the world continues to experience, such as over resources, could reemerge, **particularly if** protectionism grows and there is a resort to neo-mercantilist practices. Perceptions of renewed energy scarcity will drive countries to take actions to assure their future access to energy supplies. In the worst case, this could result in interstate conflicts if government leaders deem assured access to energy resources, for example, to be essential for maintaining domestic stability and the survival of their regime. Even actions short of war, however, will have important geopolitical implications. Maritime security concerns are providing a rationale for naval buildups and modernization efforts, such as China’s and India’s development of blue water naval capabilities. If the fiscal stimulus focus for these countries indeed turns inward, one of the most obvious funding targets may be military. Buildup of regional naval capabilities could lead to increased tensions, rivalries, and counterbalancing moves, but it also will create opportunities for multinational cooperation in protecting critical sea lanes. With water also becoming scarcer in Asia and the Middle East, cooperation to manage changing water resources is likely to be increasingly difficult both within and between states in a more dog-eat-dog world.

### Debris- Hegemony

#### CO2 increases risk of satellite-debris collisions- prefer this study- it was the first to take into account atmospheric conditions

Cheng 6 (Alicia Cheng- AP and USA today science writer, December 12 2012, “CO2 Could Extend the Life of Space Junk”, http://www.usatoday.com/tech/science/space/2006-12-12-space-junk-co2\_x.htm)//JM

Carbon dioxide emissions from global warming are cooling and shrinking the outermost atmosphere, keeping orbiting spacecraft airborne longer but also increasing the threat that space junk poses to satellites, scientists reported Monday. In a signal of the wide-ranging impacts of climate change, the thinning of the thermosphere, which begins about 60 miles above Earth and extends up to 400 miles, reduces the drag on orbiting spacecraft but also extends the lifespan of space junk — leftovers from space missions, old satellites, items astronauts lose during spacewalks and the like. "It's a bit of a two-edged sword," said Stanley Solomon, a senior scientist at the National Center for Atmospheric Research, who presented the new results at an American Geophysical Union meeting in San Francisco. Using a computer model, Solomon and his colleagues estimated that the air density of the outer atmosphere declined about 5% over the past three decades and could decrease 40% by the end of the century. Knowledge of how the outer atmosphere responds to carbon dioxide levels could help NASA and international space agencies time their spacecraft launches and calculate their fuel needs. Solomon said that a less dense outer atmosphere should not affect launches in the near term, but that it could be problematic in the future with the increase of space litter. "In the long haul, it means we have to be even more assiduous about not letting miscellaneous pieces of metal float around," Solomon said. Researchers have long predicted that carbon dioxide, produced when fossil fuels such as oil and natural gas are burned, would cool the outer atmosphere. Solomon's conclusions mirror previous research that predicted similar effects, including recent observations that measured the drag of satellites over time. Robert Dickinson, a pioneer in the field and a professor of earth and atmospheric sciences at the Georgia Institute of Technology, said the latest work is unique because it looks at the effects of solar activity on the atmosphere. An active solar cycle could spawn magnetic storms that will be more severe and disruptive to communication systems.

#### Space debris collapse the military- satellites are the backbone of our military

Imburgia 11 (Joseph Imburgia- lieutenant colonel in the US army, judge advocate for the US, May 2011, “Space Debris and Its Threat to National Security: A Proposal for Binding International Agreement to Clean up the Junk”, Vanderbilt Journal of Transnational Law, Volume 44, Number 3)

These gloomy prognostications about the threats to our space environment should be troubling to Americans. The United States relies on the unhindered use of outer space for national security. 151 According to a space commission led by former Secretary of Defense Donald Rumsfeld, “[t]he [United States] is more dependent on space than any other nation.” 152 According to Robert G. Joseph, former Undersecretary for Arms Control and International Security at the State Department, “space capabilities are vital to our national security and to our economic well-being.” 153 Therefore, a catastrophic collision between space debris and the satellites on which that national security so heavily depends poses a very real and current threat to the national security interests of the United States. Since “the [1991] Gulf War, the [United States] military has depended on satellites for communications, intelligence and navigation for its troops and precision-guided weapons.” 154 Satellites are also used for reconnaissance and surveillance, command and control, and control of Unmanned Aerial Vehicles. 155 According to the United States Space Command’s Fact Sheet: Satellites provide essential in-theater secure communications, weather and navigational data for ground, air and fleet operations and threat warning. Ground-based radar and Defense Support Program satellites monitor ballistic missile launches around the world to guard against a surprise missile attack on North America. Space surveillance radars provide vital information on the location of satellites and space debris for the nation and the world. Maintaining space superiority is an emerging capability required to protect our space assets. 156 With the modern speed of warfare, it has become difficult to fight conflicts without the timely intelligence and information that space assets provide. Space-based assets and space-controlled assets have created among U.S. military commanders “a nearly insatiable desire for live video surveillance, especially as provided from remotely piloted vehicles like the Predator and now the Reaper.” 157 Moreover, military forces have become so dependent on satellite communications and targeting capabilities that the loss of such a satellite would “badly damage their ability to respond to a military emergency.” 158 In fact, the May 2008 malfunction of a communications satellite demonstrates the fragile nature of the satellite communications system. 159 The temporary loss of a single satellite “effectively pulled the plug on what executives said could [have been] as much as 90 percent of the paging network in the United States.” 160 Although this country’s paging network is perhaps not vital to its national security, the incident demonstrates the possible national security risks created by the simultaneous loss of multiple satellites due to space debris collisions. Simply put, the United States depends on space-based assets for national security, and those assets are vulnerable to space debris collisions. As Massachusetts Democratic Congressman Edward Markey stated, “American satellites are the soft underbelly of our national security.” 161 The Rumsfeld Commission set the groundwork for such a conclusion in 2001, when it discussed the vulnerability of U.S. space-based assets and warned of the Space Pearl Harbor. 162 Congress also recognized this vulnerability in June 2006, when it held hearings concerning space and its import to U.S. national power and security. 163 In his June 2006 Congressional Statement, Lieutenant General C. Robert Kehler, then the Deputy Commander, United States Strategic Command, stated that “space capabilities are inextricably woven into the fabric of American security.” 164 He added that these space capabilities are “vital to our daily efforts throughout the world in all aspects of modern warfare” and discussed how integral space capabilities are to “defeating terrorist threats, defending the homeland in depth, shaping the choices of countries at strategic crossroads and preventing hostile states and actors from acquiring or using WMD.” 165

#### US primacy is key to maintain the liberal world order—empirics prove the alternative is catastrophe and multipolarity is destructive

Kagan 12 (Robert Kagan, Senior Fellow at the Brookings Institute, B.A., Yale University, M.P.P., John F. Kennedy School of Government, Harvard University, Ph.D., American University, March 14, 2012, “America Has Made the World Freer, Safer and Wealthier”, Brookings Institute, <http://www.brookings.edu/research/opinions/2012/03/14-us-power-kagan>, DMintz)

We take a lot for granted about the way the world looks today -- the widespread freedom, the unprecedented global prosperity (even despite the current economic crisis), and the absence of war among great powers. In 1941 there were only a dozen democracies in the world. Today there are more than 100. For four centuries prior to 1950, global GDP rose by less than 1 percent a year. Since 1950 it has risen by an average of 4 percent a year, and billions of people have been lifted out of poverty. The first half of the 20th century saw the two most destructive wars in the history of mankind, and in prior centuries war among great powers was almost constant. But for the past 60 years no great powers have gone to war. This is the world America made when it assumed global leadership after World War II. Would this world order survive if America declined as a great power? Some American intellectuals insist that a "Post-American" world need not look very different from the American world and that all we need to do is "manage" American decline. But that is wishful thinking. If the balance of power shifts in the direction of other powers, the world order will inevitably change to suit their interests and preferences. Take the issue of democracy. For several decades, the balance of power in the world has favored democratic governments. In a genuinely post-American world, the balance would shift toward the great power autocracies. Both China and Russia already protect dictators like Syria's Bashar al-Assad. If they gain greater relative influence in the future, we will see fewer democratic transitions and more autocrats hanging on to power. What about the free market, free trade economic order? People assume China and other rising powers that have benefited so much from the present system would have a stake in preserving it. They wouldn't kill the goose that lays the golden eggs. But China's form of capitalism is heavily dominated by the state, with the ultimate goal being preservation of the ruling party. Although the Chinese have been beneficiaries of an open international economic order, they could end up undermining it simply because, as an autocratic society, their priority is to preserve the state's control of wealth and the power it brings. They might kill the goose because they can't figure out how to keep both it and themselves alive. Finally, what about the long peace that has held among the great powers for the better part of six decades? Many people imagine that American predominance will be replaced by some kind of multipolar harmony. But multipolar systems have historically been neither stable nor peaceful. War among the great powers was a common, if not constant, occurrence in the long periods of multipolarity in the 16th, 17th, and 18th centuries. The 19th century was notable for two stretches of great-power peace of roughly four decades each, punctuated, however, by major wars among great powers and culminating in World War I, the most destructive and deadly war mankind had known up to that point. The era of American predominance has shown that there is no better recipe for great-power peace than certainty about who holds the upper hand. Many people view the present international order as the inevitable result of human progress, a combination of advancing science and technology, an increasingly global economy, strengthening international institutions, evolving "norms" of international behavior, and the gradual but inevitable triumph of liberal democracy over other forms of government -- forces of change that transcend the actions of men and nations. But there was nothing inevitable about the world that was created after World War II. International order is not an evolution; it is an imposition. It is the domination of one vision over others -- in America's case, the domination of liberal free market principles of economics, democratic principles of politics, and a peaceful international system that supports these, over other visions that other nations and peoples may have. The present order will last only as long as those who favor it and benefit from it retain the will and capacity to defend it. If and when American power declines, the institutions and norms American power has supported will decline, too. Or they may collapse altogether as we transition into another kind of world order, or into disorder. We may discover then that the United States was essential to keeping the present world order together and that the alternative to American power was not peace and harmony but chaos and catastrophe -- which was what the world looked like right before the American order came into being.

### Debris- Navy

#### CO2 increases risk of satellite-debris collisions- prefer this study- it was the first to take into account atmospheric conditions

Cheng 6 (Alicia Cheng- AP and USA today science writer, December 12 2012, “CO2 Could Extend the Life of Space Junk”, http://www.usatoday.com/tech/science/space/2006-12-12-space-junk-co2\_x.htm)//JM

Carbon dioxide emissions from global warming are cooling and shrinking the outermost atmosphere, keeping orbiting spacecraft airborne longer but also increasing the threat that space junk poses to satellites, scientists reported Monday. In a signal of the wide-ranging impacts of climate change, the thinning of the thermosphere, which begins about 60 miles above Earth and extends up to 400 miles, reduces the drag on orbiting spacecraft but also extends the lifespan of space junk — leftovers from space missions, old satellites, items astronauts lose during spacewalks and the like. "It's a bit of a two-edged sword," said Stanley Solomon, a senior scientist at the National Center for Atmospheric Research, who presented the new results at an American Geophysical Union meeting in San Francisco. Using a computer model, Solomon and his colleagues estimated that the air density of the outer atmosphere declined about 5% over the past three decades and could decrease 40% by the end of the century. Knowledge of how the outer atmosphere responds to carbon dioxide levels could help NASA and international space agencies time their spacecraft launches and calculate their fuel needs. Solomon said that a less dense outer atmosphere should not affect launches in the near term, but that it could be problematic in the future with the increase of space litter. "In the long haul, it means we have to be even more assiduous about not letting miscellaneous pieces of metal float around," Solomon said. Researchers have long predicted that carbon dioxide, produced when fossil fuels such as oil and natural gas are burned, would cool the outer atmosphere. Solomon's conclusions mirror previous research that predicted similar effects, including recent observations that measured the drag of satellites over time. Robert Dickinson, a pioneer in the field and a professor of earth and atmospheric sciences at the Georgia Institute of Technology, said the latest work is unique because it looks at the effects of solar activity on the atmosphere. An active solar cycle could spawn magnetic storms that will be more severe and disruptive to communication systems.

#### Navy dependent on satellites for operations

Dillon 08 (Matthew John Dillon, Lieutenant, United States Navy, B.A., California State University, “Implications of the Chinese Anti-Satellite Test for the United States Navy Surface Forces,” Naval Postgraduate School, September 2008, http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA488669)

C. UNITED STATES SPACE ASSETS AND THE NAVY’S NEED Space Security 2007 recognizes that the United States military maintains eight reconnaissance satellites in earth’s lower orbit along with other force enhancing elements such as communication and Global Positioning Satellites. See Figure 3. Naval operations depend on the following satellites to perform its missions: Intelligence/Surveillance/Reconnaissance, Communications, Position/Navigation/Timing (PNT), Space Control, Ballistic Missile Warning/Defense and Metrological and Oceanographic (METOC). 194 In terms of the overall strategic framework of Sea Power 21, a 2005 study on the current and future needs of the Navy’s space assets has identified the U.S. Navy’s space requirements as shown in Figure 4. The Navy’s primary needs in space can be summarized as the following areas: ocean and littoral surveillance, secure communications, real time measurements (GPS).196

Naval power solves multiple scenarios for nuclear war

Eaglen and McGrath 11- 5/16/11 – —Mackenzie Eaglen is Research Fellow for National Security in the Douglas and Sarah Allison Center for Foreign Policy Studies, a division of the Kathryn and Shelby Cullom Davis Institute for International Studies, at The Heritage Foundation. Bryan McGrath is a retired naval officer and the Director of Delex Consulting, Studies and Analysis in Vienna, Virginia. On active duty, he commanded the destroyer USS Bulkeley (DDG 84) and served as the primary author of the current maritime strategy. (“Thinking About a Day Without Sea Power: Implications for U.S. Defense Policy” http://www.heritage.org/research/reports/2011/05/thinking-about-a-day-without-sea-power-implications-for-us-defense-policy)

Abstract: America is a maritime power, and **a strong U.S. Navy is both in America’s long-term interest and essential to the nation’s prosperity**. Yet U.S. **sea power** is in **decline.** If not reversed, this decline **could** pass the tipping point, **l**eaving the country economically and strategically unable to reverse course, which would **have profound economic and geopolitical consequences**. Members of Congress and the Navy need to work together to develop long-range technology road maps, foster innovation, and properly fund and manage shipbuilding to ensure that the future **Navy has the size and capabilities needed to protect and advance U.S. interests around the world**. Implications of the Loss of Preponderant Sea Power How the United States might replace its preponderant sea power—if that day ever comes—seems less straightforward. Indeed, the question seems almost ludicrous. The United States is a maritime nation, bordered by two oceans and for much of its history protected by them. Over the past 60 years, **the oceans have been highways for worldwide trade that has helped to lift more than a billion people out of poverty,[3] and those sea lanes have been patrolled by the U.S. Navy, the world’s preeminent naval power**. **The U.S. Navy’s global presence has added immeasurably to U.S. economic vitality and to the economies of America’s friends and allies,** not to mention those of its enemies. **World wars**, which destroyed Europe and much of East Asia**, have become almost incomprehensible thanks to** the “nuclear taboo” and **preponderant American sea power**. **If these conditions are removed, all bets are off.** For more than five centuries, **the global system of trade and economic development has grown and prospered in the presence of some dominant naval power.** Portugal, Spain, the Netherlands, the United Kingdom, and now **the U.S.** have each taken a turn as the major provider of naval power to maintain the global system. Each benefited handsomely from the investment: [These **navie**s], in times of peace, **secured the global commons and ensured freedom of movement of goods and people across the globe**. They **support**ed **global trading systems** from the age of mercantilism to the industrial revolution and into the modern era of capitalism. They were a gold standard for international exchange. These forces supported national governments that had specific global agendas for liberal trade, **the rule of law at sea, and the protection of maritime commerce** from illicit activities such as piracy and smuggling.[4] **A preponderant naval power occupies a unique position in the global order,** a special seat at the table, which when unoccupied creates conditions for instability. **Both world wars**, **several European-wide conflicts, and innumerable regional fights have been fueled by naval arms races, inflamed by** the combination of passionate rising powers and **feckless declining powers**. In this scenario, events unfold in a world that is very unstable and unsafe. **International cooperation declines dramatically as countries hoard natural resources and the U.S. struggles against the strength of other resource-rich and economically robust regions of the world**. Like the recession of 2008, the main trigger for this catastrophe is the international finance system. In 2020, several major European nations default on their debt, causing a flight of private money from the formal financial systems of the European Union (EU), the U.S., and Japan. **Contagion in the financial markets plunges the world economy into global depression**. Virtually every major Western nation finds itself in horrific economic straits, and only nations without expansive social safety nets are able to meet current obligations. Those with robust social welfare programs face aging populations, smaller workforces, and drastic cuts in services that spill over into all sectors of their economies. The U.S. economy contracts from $20 trillion in 2020 to $12 trillion in 2025. During this time, two separate U.S. presidential Administrations seek and obtain significant cuts in the size of the U.S. armed forces. Homeland security becomes the sole focus of the Department of Defense, with policymakers concentrating primarily on port and border security, land-based strategic nuclear forces, anti-terrorism, and managing civil unrest. **Islamic terrorism accelerates the turn inward**, which had abated in the second decade of the 21st century, **as terrorists take advantage of the weakened condition of the West, especially the United States. Two “dirty bomb” explosions** in 2021 **accelerate the worldwide redeployment of U.S. military forces** to home bases as the nation demands protection from terrorism. By 2025, U.S. international influence has all but disappeared, and U.S. efforts to counter Islamic terrorism garner little worldwide support due to economic and political interests. **While the worldwide depression is devastating**, it is less so in China, which in 2015 began to rebalance its economy aggressively toward domestic consumption. A China–Russia entente dominates the international distribution of resources and is ascendant economically. A global “basket currency” replaces the dollar as the reserve currency of choice, and Southeast Asia leads in technology development. **Global maritime trade declines dramatically due to rising oil prices, terrorism, and piracy, and international cooperation to provide enhanced security does not materialize**. With the decrease in long-haul international trade, regional trade blocs become the dominant mode of commerce. Even as the depression reduces demand, supply is reduced further. The United Nations is ineffective and ignored, a relic of an age of international cooperation long since past. **Worldwide competition for declining energy resources increases**, exacerbated by a global decline in energy innovation as commercial investment slows dramatically. Industrial nations with domestic access to energy engage in power politics, creating even more conflict in an already unstable world. In this environment, Americans are not embraced internationally, and the U.S. military loses many of its basing rights as it redeploys to the United States.

### Debris EXT- Internal Link

#### Most recent analysis proves that CO2 makes attempts to remove debris not only more costly, but also ineffective

SU 7/11 (Southhampton University- citing Dr. Hugh Lewis- Lecturer in Aerospace Engineering at the University of Southampton and author of the long-term evolutionary debris model DAMAGE, lead the Group’s research on space debris modeling, represented the UK Space Agency (previously the British National Space Centre) in Working Group 2 of the Inter-Agency Space Debris Coordination Committee (IADC), And Post-grad student Arrun Saunders, July 11 2012, “Changing atmosphere increases build-up of space debris”, http://www.southampton.ac.uk/aerospace/news/2012/07/changing\_atmosphere.page)//JM

Scientists from the University of Southampton have confirmed a long-term change in the Earth's upper atmosphere at altitudes where satellites are operating. This change, a contraction of the thermosphere, has been attributed to the build-up of greenhouse gases, such as carbon dioxide, and is causing satellites - and space debris - to remain in orbit for longer than expected. Researchers led by Dr Hugh Lewis and Dr Graham Swinerd from the University's Faculty of Engineering and the Environment previously showed that this contraction can lead to an increase in collisions between satellites and orbital debris. Now the team has suggested that international efforts to control the growth of space debris may be much less effective in the future if these atmospheric changes continue. While carbon dioxide causes a global rise in temperature at the Earth's surface, it has the opposite effect in the thermosphere. Here, the temperature is dropping and there is a corresponding decrease in density. Using data from 30 satellites from the past 40 years, Southampton postgraduate student Arrun Saunders has found that atmospheric density in the thermosphere has been decreasing at a rate of five percent per decade at an altitude of 300km. The effect is greater at higher altitudes. Dr Lewis believes the decrease of atmospheric density will impact upon the effectiveness of removing space debris - which consists of man-made objects such as redundant satellites and used rocket bodies - from orbit. "As the atmospheric density in the thermosphere decreases, debris can remain in orbit for up to 25 percent longer," he says. "The fact that these objects are staying in orbit longer counteracts the positive effects that we would otherwise see with active debris removal. "Our study shows that if we double the number of debris objects we can remove each year, we can get back on track with reducing the debris population. Achieving this target, however, will be challenging." Postgraduate student Rebecca Newland adds: "Removing debris from orbit is technically very difficult and also expensive, which is why we are looking at ways to identify the best objects to remove." Work has already begun in the international space sector to develop ways of removing space debris. Dr Lewis adds: "We have already seen the positive effects that can be achieved by adopting mitigation measures. Now we have a good foundation from which we can continue to work towards the goal of limiting the growth of space debris."

#### CO2 leads to a proliferation of debris, and makes status quo prevention measures irrelevant

Raloff 11 (Janet Raloff- senior editor science news and founding board member of the Society of Environmental Journalists, managing editor of Energy Research Reports (outside Boston), a staff writer at Chemistry (an American Chemical Society magazine) and a writer/editor for Chicago's Adler Planetarium, August 15 2011, “Growing need for Space Trash Collectors”, http://www.sciencenews.org/view/generic/id/333370/title/Growing\_need\_for\_space\_trash\_collectors\_)//JM

Friction between the atmosphere and materials passing through it, known as drag force, offers the only natural means for culling detritus left in orbit by space launches. But the thermosphere — a large region of the upper atmosphere — is cooling. A resulting drop in its density is also cutting its drag force, thereby increasing the lifetime of orbiting trash (including pieces in that heavily populated band at 800 to 1,000 kilometers). Space agencies around the world have been discussing a need to actively remove aerospace debris. One reason: The number of pieces has been steadily rising, driven in part by collisions between orbiting pieces of trash or trash and spacecraft. Among the biggest debris multipliers: a spectacular 2009 crash between the dead Russian Kosmos 2251 spacecraft and the U.S. Iridium-33 telecommunications satellite. Two years ago, aerospace engineer Hugh Lewis of the University of Southampton, England, and his colleagues calculated that within a few decades, space agencies would have to begin culling perhaps five major pieces of debris annually to slow this collision-enhanced growth in the number of orbiting trash particles. But in a paper in the Journal of Geophysical Research, posted online Aug. 10, the Southampton team now doubles that number, pointing out that the thermosphere’s falling density renders the old trash-pickup requirements obsolete. Climate impacts The thermosphere does not behave as a gas, explains Lewis. Molecules originating on or near Earth’s surface are propelled upward based on their energy, he observes. With cooling, fewer of them reach satellite (and associated debris) heights. Growing emissions of carbon dioxide, a greenhouse gas, contribute to the thermosphere’s cooling, the Southampton team points out. The mechanism, Lewis says, appears to be collisions between CO2 and atomic oxygen at high altitudes. Those collisions release heat in the form of infrared energy, which radiates out into space — removing warmth from Earth’s atmosphere. A drop in the sun’s activity will also cool the thermosphere. Although the new JGR analysis assumed that solar cycles during the next 70 years would roughly match those seen over the past 30, this may prove an overly conservative assumption, Lewis acknowledges. This spring and summer, scientists have been reporting that the current solar cycle is particularly anemic. And solar activity might remain lackluster for the indefinite future. Upper atmospheric increases in carbon dioxide “is the primary cooling agent of the thermosphere,” observes thermosphere climate scientist John Emmert of the Naval Research Laboratory in Washington, D.C. The Southampton team’s new analyses, he says, “demonstrate for the first time that space climate change has significant consequences for orbital debris proliferation and for debris mitigation strategies.”

### AT: Debris Module

#### Impact is inevitable- we are passed the cascade

Imburgia 11 – Lt. Col. and Judge Advocate in Air Force

Joseph S. Imburgia, J.D., University of Tennessee College of Law (2002); LL.M., The Judge Advocate General’s Legal Center & School, U.S. Army, Charlottesville, Va. (2009)), a Judge Advocate in the United States Air Force and is presently assigned as a legal exchange officer to the Directorate of Operations and International Law, Defence Legal, Australian Defence Force, Canberra, Australia, 2011, “Space Debris and Its Threat to National Security: A Proposal for a Binding International Agreement to Clean Up the Junk,” Scholar

The “cascade effect” is “the greatest fear of those who study the problem of orbital debris.”50 Even before the February 2009 satellite collision, many scientists agreed “that the number of objects in orbit had surpassed a critical mass,”51 the point at which “orbital debris would collide with other space objects, which in turn would create new debris that would cause [a chain reaction of] even more collisions.”52 This “chain reaction” is often referred to as the cascade effect.53

#### Squo solves- Water Cannons pushing space debris out of orbit

Hollopeter 9

[James, Director of Technology Development [GIT Satellite Communications](http://gitsat.com/), 5/29/2009, “Development of A Ballistic Orbital Debris Removal System” <http://x-journals.com/2009/development-of-a-ballistic-orbital-debris-removal-system/>]

Space is filling up with trash, and it’s time to clean it up, NASA experts warn. A growing amount of human-made debris—from rocket stages and obsolete satellites to blown-off hatches and insulation—is circling the Earth. Scientists say the orbital debris, better known as space junk, poses an increasing threat to space activities, including robotic missions and human space flight. “This is a growing environmental problem,” said Nicholas Johnson, the chief scientist and program manager for orbital debris at NASA in Houston, Texas. Johnson and his team have devised a computer model capable of simulating past and future amounts of space junk. The model predicts that even without future rocket or satellite launches, the amount of debris in low orbit around Earth will remain steady through 2055, after which it will increase. While current efforts have focused on limiting future space junk, the scientists say removing large pieces of old space junk will soon be necessary. Statement of the problem: Since the launch of the Soviet Union’s Sputnik I satellite in 1957, humans have been generating space junk. The U.S. Space Surveillance Network is currently tracking over 13,000 human-made objects larger than four inches (ten centimeters) in diameter orbiting the Earth. These include both operational spacecraft and debris such as derelict rocket bodies. “Of the 13,000 objects, over 40 percent came from breakups of both spacecraft and rocket bodies,” Johnson said. In addition, there are hundreds of thousands of smaller objects in space. These include everything from pieces of plastic to flecks of paint. Much of this smaller junk has come from exploding rocket stages. Stages are sections of a rocket that have their own fuel or engines. These objects travel at speeds over 22,000 miles an hour (35,000 kilometers an hour). At such high velocity, even small junk can rip holes in a spacecraft or disable a satellite by causing electrical shorts that result from clouds of superheated gas. Three accidental collisions between catalogued space-junk objects larger than four inches (ten centimeters) have been documented from late 1991 to early 2005.The most recent collision occurred a year ago. A 31-year-old U.S. rocket body hit a fragment from the third stage of a Chinese launch vehicle that exploded in March 2000.”We’ve been fortunate that in all three cases only a few [new] debris [fragments] have been created,” Johnson said. Best-Case Scenario Previous space junk projections have assumed that new satellites and rockets would launch in the future. The new study, in contrast, looks at what would happen to the amount of space junk if no rocket bodies or spacecraft were launched in the next 200 years. “This is kind of a best-case scenario,” said lead study author Jer-Chyi Liou, principal scientist and project manager for orbital debris with the Engineering Science Contract Group at NASA’s Johnson Space Center in Houston. The results suggest that new fragments from collisions will replace the amount of objects falling out of orbit and back to Earth. Beyond 2055, however, fragments from new collisions will exceed the amount of decaying debris. “The debris population will continue to grow,” Liou said. “We know it will only get worse.” Removing Junk Johnson, the program manager for orbital debris, says space-faring nations agree that the space junk problem needs to be addressed. There is even a special organization called the Inter-Agency Space Debris Coordination Committee, made up of space agencies from ten countries and the European Space Agency. So far, efforts have concentrated on preventing new debris. Johnson believes it may be time to think about how to remove junk from space. But that is a difficult proposition. Previous proposals have ranged from sending up spacecraft to grab junk and bring it down to using lasers to slow an object’s orbit to cause it to fall back to Earth more quickly. Given current technology, those proposals appear neither technically feasible nor economically viable, Johnson admits. But, he says, the space-junk problem needs more attention. “It’s like any environmental problem,” he said. “It’s growing. If you don’t tackle it now, it will only become worse, and the remedies in the future are going to be even more costly than if you tackle it today.” Potential solution: As previously stated, many scenarios have been put forward to remove unwanted and potentially dangerous space debris from orbit. All of these techniques are, on the surface, unfeasible, beyond the scope of present technology, prohibitively expensive and in some cases would present their own hazard to legitimate orbital objects. **GIT’s proposal is to attack the problem using a sub-orbital approach that cannot add to the orbital junk problem. Based on studies done under the Space Defense Initiative in the ‘80’s and on previous anti-satellite studies, GIT proposes a sub-orbital payload lofted to the appropriate altitude that could clear or reduce existing debris from selected areas of low earth orbit. By using a ballistic launch profile, there is no chance of adding to the existing debris problem. The payload would re-enter at the end of its mission, as well as all of its lower propulsive stages.** There have been many suggestions to orbit a vehicle to collect debris and then de-orbit the debris using onboard propulsion systems. This is a very expensive approach. It would require all the associated ground control systems that are needed for any orbital missions today. By using a sub-orbital launch profile and existing sounding rockets in use today, a small ground based infrastructure, which presently exists could easily handle the launch load. There are many launch sites all over the world to support this type of mission. Since this debris problem exists for all space faring nations, the task could be shared among all users. Payload: Many payloads have been suggested to de-orbit the space debris. Most collect the debris and then de-orbit, while others such as tethers, would slowly lower the orbits until atmospheric drag takes over to de-orbit the debris. **GIT’s approach is to use water, H2O, as the passive payload. It has the highest volumetric efficiency in the payload space. It can easily and predictably be deployed and has significant mass that will be used to reduce the debris orbital momentum. The payload would be launched retrograde to the target debris orbits. The resulting collisions would easily reduce the velocity of the smaller debris. The dispersion pattern of the water in space could be easily adjusted to accommodate the required velocity reduction for the target debris. Widely dispersed for very small objects of interest or narrowly dispersed for a focused collision of larger objects. All of these dispersion techniques could easily be tested here on earth in many test areas or chambers available today.**

#### Collisions inevitable even with debris mitigation

**David 2009-** writer for space daily

[[Leonard David](mailto:newspace@aol.com) “Orbital Debris Cleanup takes Center Stage” 9/25/2009 <http://www.spacenews.com/civil/orbital-debris-cleanup-takes-center-stage.html>]

Heiner Klinkrad, head of the European Space Agency’s Space Debris Office in Darmstadt, Germany, said collisional cascading — where one collision has the potential to produce many others — is unavoidable at this point. “When we do long-term projections of the space debris environment, it turns out that space debris mitigation measures will delay — but not prevent — collisional cascading from happening in the low Earth orbit regime,” he said. “This is even so if we stop all launching activities right now … once that [cascading] process has started there is no way of controlling it again. Klinkrad said space debris remediation will be a technically demanding and expensive undertaking but such costs must be viewed in relation to the value of space assets Various orbital debris removal ideas have been championed over the years, such as shooting debris with lasers, snagging space junk with foam spheres or nets, and retrieving spent spacecraft with space tugs.

### Debris-D EXT- Debris Inev

#### Space debris inevitable

Baiocchi, 10 – Ph.D. and M.S. in optics, University of Arizona; B.S. in physics, DePaul University, also engineer and defense analyst for RAND

(Dave, “Confronting Space Debris,” pg. 30-31, RAND, 2010, http://www.rand.org/content/dam/rand/pubs/monographs/2010/RAND\_MG1042.pdf)

Problems on the right side of the spectrum can be efectively addressed using mitigation strategies. In the case of the Soviet Union and the United States, there were only two stakeholders, and their interests overlapped. As a result, the problem was easily addressed: Both countries agreed to take care not to intentionally destroy their common operating environment. Most problems, of course, cannot be categorized at either extreme and instead fall somewhere in the middle, as orbital debris does today. Since the 1960s, many countries—as well as private industry—have developed space capabilities, and that has significantly complicated the task of addressing orbital debris. Not all space-faring nations necessarily share the desire to keep the space environment risk-free. Countries Mitigation Strategies and Their Use in Other Communities 31 such as Iran or North Korea could be developing abilities to access space with the sole intent of polluting it because this would allow them to counter perceived space-based threats from the United States or another country. If Iran were to purposely create a debris cloud, it would be the blameworthy party, but it would remain relatively unaffected because its society does not have a heavy dependence on space. he burgeoning commercial space industry represents another community that is pushing the orbital debris problem closer to the middle of the spectrum shown in Figure 7.2. In the past, sovereign nation-states were the only entities with enough resources to ield a space capability. hese capabilities were developed to beneit their societies economically, scientiically, and socially. hese states recognized that space provides a variety of advantages, and they took great care to preserve the environment. hey were both the blameworthy and the afected entities. Today, commercial providers are primarily motivated by proit margins, and they may not have the best interests of their sponsoring country in mind while pursuing their business goals. he commercial provider may be the blameworthy party if it generates debris, but it may not be afected as profoundly by an accident. By contrast, a nation-state that has several hundred active assets on orbit and relies on space-based intelligence to assist ongoing military operations has much more inventory at risk.

#### Space debris inevitable – takes only one satellite to create debris, new space-faring countries, problem can never be solved.

Baiocchi and Welser 10 - \*Engineer and Defense analyst or the RAND Corporation, AND \*\* Management sytem Analyst at the RAND Corporation (2010, “Confronting Space Degree” RAND National Defense Research Institute. www.rand.org/pubs/monographs/2010/RAND\_MG1042.pdf [)](http://www.thespacereview.com/article/1735/1)

**1. Behavioral norms** (past and/or present) **do not address the problem in a satisfactory manner**.2 In other words, t**he exist- ing state of affairs does not** (and will not) **provide an accept- able solution now or in the future**. **In most industries**, there isa set of cultural and behavioral **norm**s that **govern acceptable behavio**r. These norms discourage the majority of individuals from engaging in the unwanted behavior, and the results are usually satisfactory. **However, for a problem like orbital debris, having a set of normative behaviors does not provide an accept- able solution**. For example, most of the international space com- munity agrees that creating additional debris is not acceptable. Yet**, debris creation continues to proliferate** for a variety of rea- sons, **despite the established belief that debris is damaging** to the orbital environment**. 2.The risk of collateral damage is significant**. If **a problem is not self-contained**, the actions of one party will affect another. Most often, these actions will manifest themselves as inad- vertent casualties (“collateral damage”) or damages to a third party’s property. This threat of collateral damage necessitates an infrastructure that can protect the interests of all stakehold- ers. For example**, if** the owner of **one satellite creates debris, the resulting fragments could start a chain reaction affecting other entities’ satellites and thus their capability**, capital investment, or revenue stream. 3. **There will always be an endless supply of “rule-breakers**.” Rule-breakers may violate the prevailing behavioral norms intentionally or by accident; their intent does not matter. What does matter is that the supply of rule-breakers is endless. For example, **debris has been created intentionally, by exploding lens caps, ASAT tests, or negligent command** and control (C2), **and by accident**, as when two satellites collide on orbit. Even if everyone agreed to stop creating new debris by tethering lens caps and ceasing ASAT use, existing on-orbit satellites may col- lide with one another and generate a debris cloud. In addition**, new space-faring countries may not possess the technical capa- bility** or the financial means **to effectively follow existing rules and guidelines**. In either case, it is reasonable to assume that **new debris will continue to proliferate. 4.The problem will** likely **never be** considered “**solved**” **because the root cause is difficult to eliminate.** There may be severalComparable Problems and Identifying Characteristics11 reasons behind this inability to achieve “solved” status, but the biggest is often that eliminating the root cause is technically challenging or extremely expensive. At the moment, **there is no cost-effective way to remove or relocate threatening debris in orbit**. In other cases, eliminating the root cause may simply not be an option. For example, the international community could decide to refrain from using the space environment, and debris would no longer be a concern. Obviously, this would be unac- ceptable to most space-faring corporations and governments, including the United States. **In a best-case scenario, the solution will be an asymptotic approach in which the risk is lowered to a level agreed on by all stakeholders**. **The “solution” will merely minimize collateral damage** or effects to a level that is tolerable.

### Debris-D EXT- Squo Solves

#### Russia has already allocated money to clean up space junk

City News 10

[“Russia Allocated $2 Billion to Remove Space Debris” 12/2/2010, <http://www.starcitynews.com/russia-allocated-2-billion-to-remove-space-debris/2023/>]

Natural resources are gradually declining and humans are looking for alternative means, either in the form of resources or in the form of areas to extract from. Space exploration is one of the key subjects in this aspect. Looking for a distant planet which supports human life form is a back up plan, in case the search for alternative resources fail or some catastrophe takes this earth away from us. It is said that practice makes us perfect but that notion seems to be failing in the case of space travel or alternatively it can be put it in a way that the hazards of practice are restricting the very act of space travel. Over the past 40 years since space exploration started, abandoned and obsolete man made objects have been left in orbit around the earth; these objects include rocket stages, redundant satellites, coolants released by nuclear powered engines, paint flakes and even solid rocket fuel slag. Although currently it is a manageable threat, it can seriously hinder space exploration if it is not properly dealt with. Fortunately different kind of steps have been taken to overcome this space pollution and the United States military and NASA both have agencies that are monitoring the space debris and are trying to find out a workable solution to tackle them. **Different schemes for cleaning up space debris have been presented but Russia is the first country to plan a real project and invest $2 billion on this program. Russia’s space corporation, Energia, announced a program to capture some of the thousands of pieces of dangerous debris that threaten the future of space technology. A hefty amount of $2 billion will be invested to building a special space pod which will grab around 600 defunct satellites and will push them from the orbit in a hope that they will burn on their own after entering the earth’s atmosphere.** This project will help to reopen the orbits which were previously closed due to severe pollution of debris above. The pod will travel in space through nuclear propulsion and it has an ion drive with which it gently pushes the scrap out of the orbit. The testing of the pod will be completed in 2020 and a further three years will be needed to bring it to a fully functional form. After completion it has a life span of 15 years, which means it can perform the task of cleaning for 15 whole years, effectively reducing the size of space debris. Energia is also working on similar ion technology to build an interceptor aircraft which can identify and encounter the incoming comet by derailing it from its original path by changing its trajectory so that it misses earth and burns in air.

#### Tungsten will make the atmosphere perfectly clean in 35 years

Physics arXiv 11

[The Physics arXiv Blog produces daily coverage of the best new ideas from on which scientists post early versions of their latest ideas, Published by Technology Review, “Orbiting Dust Storm Could Remove Space Junk” <http://www.technologyreview.com/blog/arxiv/26634/>]

Space junk is a serious problem, particularly in some orbits where debris is increasing at alarming rates. While there are some 900 active satellites orbiting the Earth, there are 19,000 bits of junk larger than 10 cm across. This stuff is big enough to be tracked and catalogued on the ground so that operational satellites can move away if it becomes a threat. But it's the smaller stuff that represents a more insidious threat since it cannot be seen and therefore can't be avoided. Most experts agree that there's at least an order of magnitude more of this small stuff than large bits up there. So what to do? Various organisations have suggested ways of minimising junk, such as reducing the amount of deliberately jettisoned junk such as lens caps, and by deorbiting defunct satellites or moving them into safe orbits using space tugs. But these measures will only help reduce the amount of big junk. The smaller stuff is much harder to clean up. There is a natural process that can help. Below 900km, the Earth's atmosphere generates a small but significant amount drag, which deorbits small junk in 25 years or less. So here the orbits are naturally flushed clean. But above 900km, the life time of junk stretches into centuries. Today, **Gurudas Ganguli at the US Naval Research Laboratory and a few pals describe a novel way of getting it down. Their idea is to increase the drag on the stuff above 900 km so that their orbits decay more rapidly**. That sounds perfectly sensible but their method is likely to be controversial. Their scheme is to release some 20 tons of tungsten dust at an altitude of 1100km, creating a thin shell of particles that will entirely envelop the Earth. **These tungsten particles will be just 30 micrometres across but still capable of packing a punch, tungsten being 1.7 times denser than lead. Ganguli and co say that the dust's interaction with the atmosphere will cause its orbit to decay slowly. But within 10 years or so, it should drop below the critical 900 km level. After that, it will deorbit more quickly. However, the crucial point is that the tungsten particles will naturally collide with any debris it encounters, taking this junk with it. The dust and the debris will then burn up in the Earth's atmosphere over the next 25 years or so. So over period of 35 years, the orbits up to 1100km will be scrubbed clean**. Ganguli and co call it a "dust snow plow". There's an obvious question here: **what of larger objects that get caught up in the dust storm, operational satellites, for example? Ganguli and co say the risk is manageable. First, these satellites could be designed to move above the cloud. But even if they don't move, Gangulia and co claim these spacecraft will not be significantly damaged by the dust. "Dust grains of the size proposed by NRL will certainly not penetrate thermal blankets, spacecraft structure, or sensor baffles," they say. They add that more sensitive equipment, such as the optics of Earth observing sensors or space telescopes, usually point straight up or straight down and so should be protected from dust flying in from the side. One concern is solar panels which are likely to be sand blasted by the cloud. But Ganguli and co say that panels for the next generation of spacecraft could be strengthened to cope with this kind of problem. There's also the question of the tungsten cloud's dynamics. Ganguli and co imagine it forming a shell about 30 km thick. This shell would then deorbit steadily**. But there's another possible scenario: that the tungsten band simply widens to form a cloud several hundred kilometres thick! The NRL will need to do more work on this problem. Then there is one group of people whose concerns Ganguli and co fail to address entirely in this paper: astronomers. While a cloud of tungsten particles would have little affect at visible frequencies, astronomers will want to know what kind of effect this cloud will have at other wavelengths. Is it possible that a cloud of metal particles encircling the Earth could significantly degrade our view of the Universe at certain frequencies, perhaps even acting like a giant spherical mirror? More work is needed here too. But before dismissing the proposal out of hand, the alternative has to considered. In 2007, the destruction of a defunct communications satellite at 900km by a Chinese anti-satellite weapon created, in an instant, 2400 pieces of large debris and countless smaller ones. The collision between the Iridium 33 and Kosmos 2251 satellite in 2009 created a similar amount of debris. It's likely that we'll see more events of this kind in future and the possibility of a catastrophic cascade of collisions from the debris they produce. So **Ganguli and co are presenting the space-faring world with a choice: the controlled exposure of all satellites to a low level of small collisions or the uncontrolled exposure of a few satellites to catastrophic collisions.**

### Debris-D EXT- Collisions Inev

#### NASA can prevent collisions caused by debris that can be tracked.

Ansdell, ’10 – Megan- Grad Student @ George Washington University’s Elliot School of Int’l Affairs, where she focused on space policy. “Active Space Debris Removal: Needs, Implications, and Recommendations for Today’s Geopolitical Environment,” [www.princeton.edu/jpia/past-issues-1/2010/Space-Debris-Removal.pdf](http://www.princeton.edu/jpia/past-issues-1/2010/Space-Debris-Removal.pdf).

Space debris is a specific type of space object that is human-made, no longer functional, and in Earth’s orbit. Space debris ranges in mass from several grams to many tons, and in diameter from a few millimeters to tens of meters. Fragments exist from roughly 100 to more than 36,000 kilometers above the Earth’s surface. **In 2009, NASA alone conducted nine in-orbit maneuvers to avoid potential collisions between its satellites and pieces of space debris** (NASA 2010, 2). **The most dangerous pieces of space debris are those ranging in diameter from one to ten centimeters, of which there are roughly 300,000 in orbit. These are large enough to cause serious damage, yet current sensor networks cannot track them and there is no practical method for shielding spacecraft against them. Consequently, this class of orbital debris poses an invisible threat to operating satellites** (Wright 2007, 36). **Debris larger than ten centimeters, of which there are roughly 19,000 in orbit, can also incapacitate satellites but they are large enough to be tracked and thus potentially avoided. Debris smaller than one centimeter, in contrast, cannot be tracked or avoided, but can be protected against by using relatively simple shielding** (Wright 2007, 36).

## ---Polar Melting---

### Polar Melting- Arctic War

#### Warming causes polar melting- independently causes a methane feedback that causes extinction

Connor 11 (Steve Connor- The Independent's Science Editor, November 9 2011, “Climate change melting polar regions faster than ever before One of the clearest signs of climate change is the loss of floating sea ice in the Arctic”, http://www.independent.co.uk/environment/climate-change/climate-change-melting-polar-regions-faster-than-ever-before-6259145.html)//JM

The frozen “cryosphere” of the Earth, from the Arctic sea in the north to the massive ice shelves of Antarctica in the south, is showing the unequivocal signs of climate change as global warming accelerates the melting of the coldest regions of the planet, leading polar scientists warned yesterday. A rapid loss of ice is clear from the records kept by military submarines, from land measurements taken over many decades and from satellite observations from space. It can be seen on the ice sheets of Greenland, the glaciers of mountain ranges from the Andes to the Himalayas, and the vast ice shelves that stretch out into the sea from the Antarctic continent, the experts said. The effect of the melting cryosphere will be felt by rapidly rising sea levels that threaten to flood coastal cities and low-lying nations, changes to the circulation of ocean currents such as the Gulf Stream, and possible alterations to the weather patterns that influence more southerly regions of the northern hemisphere, they said. One of the greatest threats is the melting of the permafrost regions of the northern hemisphere which could release vast quantities of methane gas from frozen deposits stored underground for many thousands of years. Scientists are already seeing an increase in methane concentrations in the atmosphere that could be the result of melting permafrost, they said. “The melting of the cryosphere is such a clear, visibly graphic signal of climate change. Almost every aspect is changing and, if you take the global average, it is all in one direction,” said Professor David Vaughan, a geologist at the British Antarctic Survey in Cambridge. One of the clearest signals of climate change is the rapid loss of floating sea ice in the Arctic, which has been monitored by satellites since the late 1970s and by nuclear submarines since the beginning of the cold war, said Professor Peter Wadhams of Cambridge University, one of the first civilians to travel under the Arctic sea ice on a nuclear submarine. The sea ice is retreating faster and further than at any time on record and this year it probably reached an all-time record minimum in terms of volume and a close second in terms of surface area. On current projections, if the current rate of loss continues, there could be virtually no September sea ice as early as 2015, Professor Wadhams said at a briefing held at the Science Media Centre in London. “The changes are more drastic that we thought. The effect is more dramatic than if you just look at the surface area of the ocean covered by sea ice. Submarine records show a big area north of Greenland is reduced in sea ice thickness,” Professor Wadhams said. The loss of sea ice and the warming of the Arctic region is having an impact on the permafrost regions of the north, both on land and in the shallow sea above the continental shelf of northern Russia, he said. Scientists have documented vast methane releases both on land and above the sea. “Methane is 23 times more potent as a greenhouse gas than carbon dioxide. We can expect the possibility of a methane boost to global warming. We have to warn about the loss of sea ice, and the retreat is accelerating,” Professor Wadhams said. One of the greatest threats in the coming century will be the possible rapid rise in sea levels as a result of melting mountain glaciers and polar ice sheets. Scientists believe that about two thirds of the current rate of average sea level rise, about 3 millimetres a year, is the result of melting ice, both from mountain glaciers and polar ice sheets. “In a warmer world, one thing you can guarantee is that ice will melt. Sea levels are now rising at a third of the rate they were when we had truly massive ice sheets at the end of the last ice age,” said Chris Rapley, professor of climate science at University College London, and a former head of the British Antarctic Survey.

#### This makes arctic war inevitable- multiple scenarios for conflict

Brandt 12 (Kate Brandt- Gates Cambridge Scholar and previously served as a policy analyst in the White House Office of Energy and Climate Change, January 2012, “Climate Change in the Arctic Brings Potential Conflict Between the U.S. and Russia”, http://www.policymic.com/articles/3576/climate-change-in-the-arctic-brings-potential-conflict-between-the-u-s-and-russia)//JM

Climate change in the Arctic is creating new international challenges that the U.S. must be prepared to meet, both through cooperation and preservation of our national interests. In the city of Nome, Alaska, extreme weather in the Arctic Circle led to international cooperation; however, this may not always be the case. Significant polar ice cap melt is another weather extreme of the region, which creates newly accessible shipping lanes, as well as oil and gas resources. In 2004, an international team of scientists published the Arctic Climate Impact Assessment (ACIA). The report found that over the past few decades, the average temperature in the Arctic has risen nearly twice as fast as the temperatures in the rest of the world and concluded that the summer polar ice cap could melt completely before the end of this century. A reduction in sea ice will likely increase access to the region’s precious natural resources, both expanding opportunities for international shipping as well as for offshore oil drilling. The U.S. Geological Survey estimates that 13% of the undiscovered oil and 30% of the undiscovered natural gas resides in the arctic. These new opportunities bring international competition. For instance, Russia claims that an underwater mountain known as the Lomonosov Ridge is actually an extension of the Russian state. Artur Chilingarov, a famous Russian explorer, led the mission to plant a Russian flag in a capsule on the ocean seabed under the North Pole. "The Arctic is Russian," Chilingarov said. "We must prove the North Pole is an extension of the Russian coastal shelf." At the moment, no particular nation’s shelf officially extends up to the North Pole. There is an international zone around the Pole that is managed by the International Seabed Authority based in Kingston, Jamaica. In addition to the Russian claim, the U.S. and Canada dispute rights to the Northwest Passage. Canada is also clashing with Denmark over a small island off Greenland, and Denmark claims the North Pole as its own. A recent Government Accountability Office report looks at U.S. preparation for operations in an Arctic with increasing human activity, and the potential for increasing international tensions. The report warns that although the Department of Defense has begun to assess the capabilities required to operate in this region, more is required, including developing a risk-based investment strategy and a timeline for developing Arctic capabilities and establishing a forum with the Coast Guard to identify collaborative Arctic capability investments. The GAO report’s findings must be taken seriously, but the model of cooperation in a changing Arctic landscape offered by the Renda should also not be ignored.

#### World War 3

Rodgers 10 – former senior international correspondent for CNN (Walter, “War over the Arctic? Global warming skeptics distract us from security risks.” 3/2/10; <http://www.csmonitor.com/Commentary/Walter-Rodgers/2010/0302/War-over-the-Arctic-Global-warming-skeptics-distract-us-from-security-risks>)//AB

Skepticism about climate change is going mainstream, and that is worrying. One-third of Americans now say global warming doesn’t exist – triple the percentage of three years ago. This defiance of science isn’t just harmful for the environment. It’s also distracting us from **growing threats to US national security. Actual – not theoretical – effects of climate change are turning the Arctic into a potential military flash point. Expected melting of summer sea ice in the** [Arctic Ocean](http://www.csmonitor.com/tags/topic/Arctic+Ocean) **means greatly expanded access to increasingly scarce fossil fuels. It also means tensions over Arctic real estate**. What the [Middle East](http://www.csmonitor.com/tags/topic/Middle+East) was to the second half of the 20th century, the Arctic could be to the first half of the 21st. **Because America has been so slow to wake up to climate change, it’s lagging behind in protecting its Arctic interests**. “Since 1995 we have lost 40 percent of the [North Pole](http://www.csmonitor.com/tags/topic/North+Pole)’s icecap,” said [Professor Robert Huebert](http://www.csmonitor.com/tags/topic/Robert+Huebert), of the [University of Calgary](http://www.csmonitor.com/tags/topic/University+of+Calgary) and an adviser to the Canadian government. Mr. Huebert and other experts spoke at a recent conference on climate change security risks hosted by the [Center for National Policy](http://www.csmonitor.com/tags/topic/Center+for+National+Policy). “**It is not a matter of if, but when, the ice will be gone,”** he said. [Moscow](http://www.csmonitor.com/tags/topic/Moscow) gets this, even if the US public does not. “**The Arctic must become** [Russia](http://www.csmonitor.com/tags/topic/Russia)**’s main strategic resource base**,” [Nikolai Patrushev](http://www.csmonitor.com/tags/topic/Nikolai+Patrushev), the **secretary of the** [Russian Security Council](http://www.csmonitor.com/tags/topic/Security+Council+of+the+Russian+Federation), declared last year. “**It cannot be ruled out that the battle for raw materials will be waged by military means,”** a Russian planning document has warned. Partially because of years of climate change denial, “the [United States](http://www.csmonitor.com/tags/topic/United+States) remains largely asleep at the wheel,” according to a Foreign Affairs article last March by Scott Borgerson, a fellow at the [Council on Foreign Relations](http://www.csmonitor.com/tags/topic/U.S+Council+on+Foreign+Relations). **Meanwhile, other Arctic nations are moving to muscularly stake their sovereignty claims while prospecting for hundreds of billions of dollars of treasure buried on the ocean floor up there. Major melting has spurred Russia, Canada,** [Denmark](http://www.csmonitor.com/tags/topic/Denmark) **(via Greenland), and Norway into a new gold rush, except this time it’s about staking claim to huge reservoirs of natural gas, petroleum, and untold deposits of minerals previously inaccessible because of the polar ice shield**. Much of the sub-sea Arctic wealth will of necessity be transported by ships because thawing tundra will be too unstable for pipelines. The South Koreans anticipated this more than a decade ago, building giant vessels to secure a big share of the shipping market. The US and other Arctic nations are meeting this month to discuss Arctic sovereignty. Previous summits have included agreements to act responsibly and peacefully as the polar icecap recedes, but nearly all nations involved are rearming militarily to defend their sovereignty. “We are already in an Arctic arms race,” Huebert says. “**The year 2010 in the Arctic is akin to 1935 in Europe**.” **Russia is building military bases on the Arctic coast and has 10,000 troops deployed near its northern border to assert its expanding claims. Norway has in recent years bought five new supermodern Navy frigates with advanced Aegis weapons systems to defend its undersea claims. Denmark is also increasing military spending to support its polar position**. Because of the vagueness of undersea borders, the US and Canada are also arguing about overlapping sovereignty claims with hundreds of billions in petro profits hanging in the balance. **China has no polar border, yet it is building an advanced icebreaker to promote “scientific “and “commercial’ pursuits both in the Arctic and Antarctic regions. Former** [US Sen. Gary Hart](http://www.csmonitor.com/tags/topic/Gary+Hart) **is worried that the Arctic could become the new Fulda Gap, the cold-war fulcrum of potential battle in** [Germany](http://www.csmonitor.com/tags/topic/Germany)**, where the West feared Soviet divisions would pour into** [Western Europe](http://www.csmonitor.com/tags/topic/Western+Europe)**. “**We don’t need to start another cold war,” Mr. Hart said, “but we do need to determine Russia’s intent.” **As the Arctic thaws and the Northwest Passage becomes a navigable strait for shipping, there could be seismic consequences. Under international law, the term “strait” also affords flyover rights to other countries. When the Northwest Passage becomes a regularly navigable strait, Russia could legally and perhaps provocatively send its warplanes into North American airspace, something it never would have done in the cold war.** Canadian political experts claim the **Russians are already becoming more assertive, bordering on aggressive.** “**If that’s the case, the Russians need to be stopped now**,” Huebert said. “Most Americans have no clue the United States is an Arctic nation,” said [US Coast Guard](http://www.csmonitor.com/tags/topic/U.S.+Coast+Guard) Rear Adm. Gene Brooks. Such ignorance carries a heavy price. Yet broader public ignorance about climate change is the goal of some skeptics and deniers. It wasn’t that long ago when cigarette manufacturers told Congress that nicotine wasn’t addictive, or when [Detroit](http://www.csmonitor.com/tags/topic/Detroit)’s auto moguls insisted that seat belts were a bad idea. Responsible dissent is one thing. But defiance of facts on the ground that imperil US national and energy security is quite another. Says Brooks: “The age of the Arctic is upon us.”

### Polar Melting EXT- Polar Melting Now

#### Unprecedented polar melting happening now- multiple climate sats and data models prove

NASA 7/24 (National Aeronautics and Space Administration, July 24 2012, “Satellites See Unprecedented Greenland Ice Sheet Surface Melt”, <http://www.nasa.gov/topics/earth/features/greenland-melt.html>)//JM

For several days this month, Greenland's surface ice cover melted over a larger area than at any time in more than 30 years of satellite observations. Nearly the entire ice cover of Greenland, from its thin, low-lying coastal edges to its two-mile-thick center, experienced some degree of melting at its surface, according to measurements from three independent satellites analyzed by NASA and university scientists. On average in the summer, about half of the surface of Greenland's ice sheet naturally melts. At high elevations, most of that melt water quickly refreezes in place. Near the coast, some of the melt water is retained by the ice sheet and the rest is lost to the ocean. But this year the extent of ice melting at or near the surface jumped dramatically. According to satellite data, an estimated 97 percent of the ice sheet surface thawed at some point in mid-July. Researchers have not yet determined whether this extensive melt event will affect the overall volume of ice loss this summer and contribute to sea level rise. "The Greenland ice sheet is a vast area with a varied history of change. This event, combined with other natural but uncommon phenomena, such as the large calving event last week on Petermann Glacier, are part of a complex story," said Tom Wagner, NASA's cryosphere program manager in Washington. "Satellite observations are helping us understand how events like these may relate to one another as well as to the broader climate system." Son Nghiem of NASA's Jet Propulsion Laboratory in Pasadena, Calif., was analyzing radar data from the Indian Space Research Organisation's (ISRO) Oceansat-2 satellite last week when he noticed that most of Greenland appeared to have undergone surface melting on July 12. Nghiem said, "This was so extraordinary that at first I questioned the result: was this real or was it due to a data error?" Nghiem consulted with Dorothy Hall at NASA's Goddard Space Flight Center in Greenbelt, Md. Hall studies the surface temperature of Greenland using the Moderate-resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aqua satellites. She confirmed that MODIS showed unusually high temperatures and that melt was extensive over the ice sheet surface. Thomas Mote, a climatologist at the University of Georgia, Athens, Ga; and Marco Tedesco of City University of New York also confirmed the melt seen by Oceansat-2 and MODIS with passive-microwave satellite data from the Special Sensor Microwave Imager/Sounder on a U.S. Air Force meteorological satellite. The melting spread quickly. Melt maps derived from the three satellites showed that on July 8, about 40 percent of the ice sheet's surface had melted. By July 12, 97 percent had melted. This extreme melt event coincided with an unusually strong ridge of warm air, or a heat dome, over Greenland. The ridge was one of a series that has dominated Greenland's weather since the end of May. "Each successive ridge has been stronger than the previous one," said Mote. This latest heat dome started to move over Greenland on July 8, and then parked itself over the ice sheet about three days later. By July 16, it had begun to dissipate. Even the area around Summit Station in central Greenland, which at 2 miles above sea level is near the highest point of the ice sheet, showed signs of melting. Such pronounced melting at Summit and across the ice sheet has not occurred since 1889, according to ice cores analyzed by Kaitlin Keegan at Dartmouth College in Hanover, N.H. A National Oceanic and Atmospheric Administration weather station at Summit confirmed air temperatures hovered above or within a degree of freezing for several hours July 11-12. "Ice cores from Summit show that melting events of this type occur about once every 150 years on average. With the last one happening in 1889, this event is right on time," says Lora Koenig, a Goddard glaciologist and a member of the research team analyzing the satellite data. "But if we continue to observe melting events like this in upcoming years, it will be worrisome."

### Arctic War D- Generic

#### War in the Arctic is impossible – international cooperation checks escalation.

Kraska 11 – US Navy Commander Chair of Operational Law and member of the International Law Department (Commander James, “Arctic Security in an Age of Climate Change” 2011; <http://books.google.com/books?id=b-U1To97zqsC&printsec=frontcover#v=onepage&q&f=false>)//AB

Still, armed **conflict in the Arctic is improbable**. The National Intelligence Council, for example, suggests, that major war in the Arctic is unlikely, although small-scale conflict- the result of spillover from disputes in other areas gravitating into the Arctic region- is possible. **All** **of the A5 states’ parties in good standing with the UN Convention on the Law of the Sea (UNCLOS), except the United States- and even Washington observes almost all of the provisions of the convention**. At a conference in Moscow in September 2010, Russian Premier Vladimir Putin stressed that any disagreements in the region can be solves under the framework of UNCLOS, and furthermore that no Russian development projects would proceed in the Arctic without strict measures to ensure the fragile environment is protected. Putin also stated that, although serious geopolitical and economic interests intersect in the Arctic, the prospects were high that the issues could be solved in a spirit of cooperation and partnership. Scenarios for future war in the Arctic have “nothing to do with reality,” Putin stressed.

#### Specifically in the context of an Arctic oil rush, Arctic nations will cooperate.

DoD 11 – US Department of Defense (“Report to Congress on Arctic Operations and the Northwest Passage” May 2011; < http://www.defense.gov/pubs/pdfs/Tab\_A\_Arctic\_Report\_Public.pdf>)//AB

The extent, impact, and rate of climate change in the Arctic are uncertain, and may not unfold in a linear fashion. This will make it challenging to plan for possible future conditions in the region and to mobilize public or political support for investments in U.S. Arctic capabilities or infrastructure absent a clear and immediate need for them. The general assumption that climate change will occur gradually, allowing plenty of time to adapt, may be overturned by periods of rapid change punctuated by episodes of climatic stability, or by unexpectedly severe impacts from the change. Part of the challenge will be the variable pace of climate change: several relatively ice-free summers may be followed by a number of unusually cold years during which the sea ice remains throughout the year. Relationships among the Arctic nations will remain generally stable and cooperative. All five littoral nations (United States, Russian Federation, Canada, Norway, and Denmark on behalf of Greenland) have already established the groundwork of common approaches to managing the region within the framework of the UN Convention on the Law of the Sea, the International Maritime Organization (IMO), the Arctic Council, and other international forums. All of the Arctic states (the five littoral nations plus Iceland, Sweden, and Finland) have shown through their participation in the Arctic Council, the Barents Euro-Arctic Council, the IMO, and other international organizations a willingness and ability to manage and resolve disputes through established international diplomatic mechanisms. This provides a sound basis to anticipate that the security environment in the Arctic will be defined by cooperation rather than conflict in the future. Should military security issues arise, they will be addressed with the appropriate stakeholders through the network of relevant bilateral and multilateral relationships.

#### All Arctic states are cooperating with the US – even Russia is playing along.

O’Rourke 6/15 – Specialist in Naval Affairs (Ronald, “Changes in the Arctic: Background and Issues for Congress”, 6/15/12; < http://www.fas.org/sgp/crs/misc/R41153.pdf>)//AB

**Of the other Arctic coastal nations, the United States enjoys strong political and commercial ties with Canada, Norway, and Denmark; all four countries are members of NATO.** Although the **United States views Russia as an important partner in developing policies to cope with changing conditions in the Arctic**, relations with Moscow have been somewhat problematic in recent years, particularly in the wake of Russia’s August 2008 incursion into South Ossetia and Georgia, and its cutoff of natural gas to Ukraine and Europe.165 The two nations have also been at odds over Washington’s plans to install in Europe missile defense facilities intended to guard against missiles launched from Iran. In February 2009, Vice President Joseph Biden stated the Obama Administration’s intention “to pre**ss the reset button and to revisit the many areas where we can and should work together**.”166 **Washington has sought to engage Russian cooperation in negotiations with North Korea**. Also, in support of U.N. sanctions, Moscow has cancelled the proposed sale of its S-300 anti-aircraft missiles to Iran. In addition, Russia is permitting nonlethal supplies to be transported across its territory to NATO forces in Afghanistan. In April 2010, the two countries signed the New Start Treaty; the accord was ratified by the U.S. Senate in December 2010. Finally, at the NATO-Russia Council meeting, held in conjunction with the alliance’s November 2010 summit in Lisbon, **NATO and Moscow endorsed cooperation** in the area of missile defense.

#### **All Arctic states want cooperation – no arms race.**

Holtsmark, 09 – is the Deputy Director at the Norwegian Institute for Defense studies. (Sven G., “Towards cooperation or confrontation: Security in the High North,” Research Paper, Research Division – NATO Defense College, Rome – No. 45, February 2009 // JH)

The discussion above of military aspects of High North security should not distract from the overall message of this paper: there is no ongoing "race" for High North resources, nor is there a visible threat of a "grab" for still undivided Arctic Ocean areas. Until now, the Arctic Ocean has been an area of stability, characterized by a web of bilateral and multilateral regimes. There are many good reasons to believe that this benign state of affairs can be maintained. Most importantly, Russia shares the West's fundamental interest in maintaining the High North as an area characterized by international cooperation and the absence of military confrontation. Like all the other Arctic littoral states, Russia also considers that the United Nations Convention on the Law of the Seas, UNCLOS, provides the overall legal framework for the Arctic Ocean region. It can be taken for granted that Russia would like the High North to remain the country's most stable and conflict-free border region. Managing relations with Russia will be both the key to - and the measure of - success or failure in securing continued prosperity and stability in the High North. Full use should be made of hard-won lessons from the era of strategic confrontation during the cold wait and from the ups and downs of managing relations with Russia since the 1990s." This will require the skillful calibration of political and military means to reach a defined set of fundamental aims. Western policy makers must demonstrate the ability and will to take Russian foreign and security interests into account as the Russians themselves perceive them, without necessarily accepting them at face value." The West and NATO should be unanimous in their resolve to engage Russia in constructive cooperation over the broadest spectrum of security-related issues. The NATO Russia Council may be one important arena for constructive High North dialogue. But there is still the residual risk that conflicts of interests may develop into armed confrontation, through escalation or otherwise. However unlikely, it cannot be excluded that a major conflict elsewhere may spill over into armed aggression in the High North. Thus, the High North is one of several areas where NATO needs to examine how the Alliance's core function - the idea of collective defense presented by the Washington Treaty's Article 5 - ought to be interpreted and implemented in the post cold-war setting. Surveillance and intelligence and deterrence including contingency planning must remain core elements of the Western Alliance's military posture in the High North. The difficult task will be to find ways to back up declarations of intent through necessary adjustments to current policies without jeopardizing the ultimate goal of preventing the use of armed force in the High North. All decisions must be guided by a firm intent to avoid a return to the chess-board reasoning of the cold war, which presupposed that only one winner would be left on the field. This will involve multiple balancing acts between demonstrations of Allied solidarity and preparedness and the danger that they may provoke destabilizing Russian countermeasures. The approach should be analytical rather than emotional. All steps should be calculated in terms of their long-term effect on High North security and stability, and they should be predictable and legitimate in terms of the Western countries' declared policy aims. Military measures have the negative aim of avoiding the worst. Positive ambitions can only be achieved through dialogue, cooperation and compromise solutions to matters under dispute.

#### Arctic conflicts will remain purely diplomatic.

Byron, 12 -- a John Gardner Fellow at the U.S. Department of State in the Office of Global Change working on adaptation measures to climate change. He graduated Phi Beta Kappa in May 2011 with a B.A. in Political Science, a B.S. in Society & Environment. In addition to receiving Highest Honors in political science for his honors thesis, Byron was awarded Highest Distinction in General Scholarship for both of his degrees. (Ruby, “Conflict or Cooperation? Arctic Geopolitics and Climate Change,” Berkeley Undergraduate Journal, Office of Undergraduate Research, UC Berkeley, Peer Reviewed, 2012, <http://escholarship.org/uc/item/6z7864c7> // JH)

Within the existing literature on Arctic geopolitics and climate change, few authors explicitly define what they mean by "conflict." In fact, the term is often thrown around loosely, sometimes referring to a state of armed warfare or at other times to conflict of the political or diplomatic kind. While these uses are certainly legitimate and within the established meaning of the word, it makes for fuzzy boundaries and ambiguous projections: the chance or likelihood of future diplomatic "conflict," whatever that is intended to mean, most certainly differs—and probably differs starkly—from the chances of total war between two Arctic nations. Thus, for the purposes of this research, unless otherwise specified, conflict is defined as a militarized confrontation between at least two countries. No shots need be fired, nor do casualties need to be suffered. A formal declaration of war would also be too high of a standard for "conflict," as that would exclude such prominent wars like those in Korea, Vietnam, and the Persian Gulf on the basis of what has become in many respects a dispensable procedural formality. Rather, the mere formal invocation of some form of coercive force is sufficient to qualify an event as a form of conflict (e.g. ordering a ship to fire across the bow of another ship belonging to another nation). A baseline example of what would constitute a conflict, then, is the Turbot War of 1995 between Canada and Spain, where the Canadian Navy boarded a Spanish fishing vessel and arrested its crew for fishing in Canada’s Exclusive Economic Zone off the coast of Newfoundland (Nordås & Gleditsch 2007, 631). In this respect, this definition of conflict differs slightly from the typical notion of "war," which tends to connote much greater military mobilization and the number of causalities being greater than zero (Bremer 1992, 310). The logic for narrowing the scope of conflict in this respect is twofold. First, while there has certainly been a history of diplomatic dispute in the Arctic, there has yet to be any form of armed brinksmanship or militarized conflict to date—at least not since the fall of the Soviet Union in 1991. This leaves such future-facing projections on armed conflict—such as this research— still a relevant exercise. Second, it creates a clear distinction between what does constitute "conflict" and what does not. Definitions of conflict seeking to make qualitative judgments on the degree, size, or escalation of conflict inevitably invite criticism in terms of the arbitrariness of the line that renders some conflicts authentic and others as something else altogether.

#### DoD report confirms; current military infrastructure is adequate in the Arctic.

DoD 11 – US Department of Defense (“Report to Congress on Arctic Operations and the Northwest Passage” May 2011; < http://www.defense.gov/pubs/pdfs/Tab\_A\_Arctic\_Report\_Public.pdf>)//AB

In summary, **with the low potential for armed conflict in the region in the foreseeable future, the existing defense infrastructure (e.g., bases, ports, and airfields) is adequate to meet near- to mid-term U.S. national security needs**. Therefore, DoD does not currently anticipate a need for the construction of additional bases or a deep draft port in Alaska between now and 2020. Given the long lead times for basing infrastructure in the region, DoD will periodically re-evaluate this assessment as activity in the region gradually increases and the CCDRs review and update their regional plans as the security environment evolves.

#### No risk of arctic conflict

DOD 11- (“report to congress on arctic operations and the northwest passage”, May 11, <http://www.dot.state.ak.us/stwddes/desports/assets/pdf/dodreport_arcticops.pdf>)//MSO

Relationships among the Arctic nations will remain generally stable and cooperative. All five littoral nations (United States, Russian Federation, Canada, Norway, and Denmark on behalf of Greenland) have already established the groundwork of common approaches to managing the region within the framework of the UN Convention on the Law of the Sea, the International Maritime Organization (IMO), the Arctic Council, andother international forums. All of the Arctic states (the five littoral nations plus Iceland, Sweden, and Finland) have shown through their participation in the Arctic Council, the Barents Euro-Arctic Council, the IMO, and other international organizations a willingness and ability to manage and resolve disputes through established international diplomatic mechanisms. This provides a sound basis to anticipate that the security environment in the Arctic will be defined by cooperation rather than conflict in the future.Should military security issues arise, they will be addressed with the appropriate stakeholders through the network of relevant bilateral and multilateral relationships

#### Current Arctic ports are enough for deterrence – DoD agrees.

DoD 11 – Department of Defense (“Report to Congress on Arctic Operations and the Northwest Passage”, May 2011; < http://www.defense.gov/pubs/pdfs/Tab\_A\_Arctic\_Report\_Public.pdf>)//AB  
**In summary, with the low potential for armed conflict in the region in the foreseeable future, the existing defense infrastructure (e.g., bases, ports, and airfields) is adequate to meet near- to mid-term U.S. national security needs.** **Therefore, DoD does not currently anticipate a need for the construction of additional bases or a deep draft port in Alaska between now and 2020.** Given the long lead times for basing infrastructure in the region, DoD will periodically re-evaluate this assessment as activity in the region gradually increases and the CCDRs review and update their regional plans as the security environment evolves.

### Arctic War D- Canada Alt Cause

#### Main instances of Arctic conflict will be isolated to Canada.

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In reviewing this data, several notable trends are worth pointing out. First, there has been no history of armed conflict among the five Arctic nations in the past twenty years and all have established diplomatic relations. No country is left unrecognized or left as a pariah; and no recent armed conflicts exist to severely taint the dyadic relationships, even if flashbacks of Cold War emerge within policy discussions concerning Russia. Generally speaking, the absence of war and maintenance of diplomatic recognition is an auspicious sign for cooperation, given the previous analysis of what these indicators signal. Second, the Arctic nations all possess relatively democratic institutions. Among this sample of five, Russia is the outlier with a combined score of 83, while the other four cluster around the high-end percentiles, indicating robust democracies and respected civil and political rights. It is difficult, however, to determine whether or not the absolute difference in Russia’s score from the other nations’ scores is sufficient enough to incur the dangers that arise in democratic-autocratic dyads, which are notoriously conflict-prone. Third, despite similar levels of democracy and lack of conflict in recent decades, there are rather stark differences in terms of numbers of bilateral agreements. The United States and Canada have the highest number of overall agreements or treaties in force at three hundred and fifty-seven. Moreover, the rate of diplomatic activity between the U.S. and Canada has been increasing, as 26% of the total treaties were formulated during the past twenty years despite possessing a formal diplomatic relationship spanning over a century. But that is not just unique to the U.S. and Canada; rather, a trend has emerged where the U.S. has forged roughly one-quarter of all its total agreements with the other Arctic littoral states in the past twenty years: approximately 27% of its total number with Norway and approximately 23% of its total number with Denmark. Russia stands as an exception, insofar as the state only came into official diplomatic existence within the past twenty years. Despite profuse diplomatic activity with the United States, Canada’s other interstate relationships are more lacking in terms of the amount of bilateral agreements. What is particularly noteworthy is Canada’s total number of agreements with Russia, which is the minimum number of total agreements for any dyad, and Canada’s number of agreements made in the past twenty years with Denmark, which is only 10% of its total number. This last figure indicates that diplomatic activity has been substantially lower with Denmark in recent years, and is in fact well below the mean rate of diplomatic activity among other Arctic littoral states especially with Denmark. Fourth, levels of bilateral trade vary greatly among the dyads, in part because the size of each respective country’s economy differs with substantial variance. Since the United States has the largest economy in the world, it is generally the top importer for each of the other countries, barring Norway, which imports similar amounts from Denmark—whose economy is only a fraction of the economy of the United States, at about 2% of U.S. gross domestic product (GDP). This alone indicates a proportionally strong trading relationship between Denmark and Norway. A better measurement of interdependence is found in Figures 6-8. These graphs show the export levels as a percentage of the sender country’s GDP. Using Microsoft Excel, I calculated the changes in these ratios with total GDP data by country from the International Monetary Fund (IMF). Split up into three graphs for visual ease, the first group of percentage lines cluster around 2% of senders’ GDPs, while the second group in Figure 7 cluster around 0.1% of senders’ GDP. The one outlier in this group is Canada’s export-to-GDP ratio, which sits around 20% to 30% of its GDP (and therefore receives its own separate graph for visual ease and scalar coherence). This indicates a strong degree of economic interdependence between the United States and Canada, although the trend indicates that this dependence may be lessening slightly. Several other observations are worth noting. In the U.S.-Russia dyad, the export-to-GDP ratio is dropping while overall bilateral trade is increasing. What appears, then, to be a paradox can be explained by the fact that Russia’s overall GDP is increasing rapidly, outpacing the amount that it proportionally trades with the United States. Next, the three dyads of Russia-Norway, Canada-Russia, and Canada-Denmark have not only the lowest levels of bilateral trade (with the lowest being Canada’s export level to Denmark), but these dyads also possess the lowest export-to-GDP ratios, barring those caused by skews in sheer size of base GDP (for example, Denmark’s export to-GDP ratio with the U.S. is high relative to the concomitant export-to-GDP ratio the U.S. has with Denmark, which was the absolute lowest ratio). Russia’s export-to-GDP ratio with Canada and Canada’s export-to-GDP ratio with Denmark were the next lowest, both at roughly 0.04%. In summary, this dyadic analysis shows that the Arctic states enjoy relatively stable relations. Every state—endowed with strong institutions and exceptionally high levels of political freedom, with the exception of Russia—recognizes, trades with, and makes diplomatic entreaties with each of the other states. Of the ten dyads, two are particularly strong on almost all accounts: U.S.-Canada and Denmark-Norway. Their dyads boast robust levels of trade, diplomatic engagement, similarly high Freedom House scores, and no history of conflict or diplomatic withdrawal. The strength of these dyads suggests there needs to be less concern over these states entering into armed conflict, given the high level of political alignment and economic interdependence. Three dyads, however, are worth paying attention to as potential hotspots: Denmark-Canada, Canada-Russia, and, to a lesser extent, Russia-Norway. Denmark-Canada has some of the lowest absolute trade levels (and resulting export-to-GDP ratios) as well as a decreasing rate of diplomatic activity in the past twenty years. But, Denmark and Canada have relatively similar Freedom House scores, which constitute a point of distinction with Canada-Russia and Russia-Norway, whose Freedom House scores differ the most of the five states evaluated and whose trade levels are also comparatively low. That said, it should be reiterated that lower trade levels are not necessarily cause for conflict (and it would certainly be myopic to label any of these trade levels as ‘low’ in anything but a relative sense). Rather, lower levels of trade simply suggest that the costs of going to war are lower, since there is less to lose from war’s destructive interference (or perhaps the threat of unilateral sanctions from increasingly belligerent militarized activity). That said, there would still need to be a casus belli, which serves as a perfect segue to the evaluation of recent Arctic disputes.

#### Alt cause – Canada is going to start the new Arctic war with Russia.

Byron, 12 -- a John Gardner Fellow at the U.S. Department of State in the Office of Global Change working on adaptation measures to climate change. He graduated Phi Beta Kappa in May 2011 with a B.A. in Political Science, a B.S. in Society & Environment. In addition to receiving Highest Honors in political science for his honors thesis, Byron was awarded Highest Distinction in General Scholarship for both of his degrees. (Ruby, “Conflict or Cooperation? Arctic Geopolitics and Climate Change,” Berkeley Undergraduate Journal, Office of Undergraduate Research, UC Berkeley, Peer Reviewed, 2012, <http://escholarship.org/uc/item/6z7864c7> // JH)

This research sought to test the claims made by Borgerson and other realists who speculated a nascent Arctic resource race would erupt into outright conflict. The results of this research suggest that, instead, a clear trend of cooperation has begun to emerge. In only two of the quantitative simulations were the chances for militarized conflict above 10%, and one of those disputes—Russia and Norway in the Barents Sea—has been more or less resolved at the time of this writing, while the other dispute—the U.S. and Canada over the Northwest Passage—is situated within one of the strongest interstate dyads. Moreover, the dyadic analysis suggests that all of the dyads are relatively strong, especially with respect to open trade, levels of democracy, and normalized relations. It should be noted that at no point did any of these countries retract or withdraw diplomatic envoys—a sign of a severe or catastrophic breakdown in diplomacy— during the course of any of the studied territorial disputes. However, this research does reveal a slightly less reassuring trend regarding Canada and, to a lesser extent, Russia. Not only is Canada embroiled in three of the four current Arctic disputes, but it is also part of two of the weakest dyads identified in the dyadic analysis. Indeed, it appears that, when compared to the other Arctic nations, it is the most aggressive nation-state, even more so than the oft-distrusted Russian bear (whose most portentous indicator of conflict— the nearly 20% chance of armed conflict with Norway—has been muted by a recent treaty formally resolving the dispute). Should policymakers be concerned? Does Canada pose a threat to Arctic security and cooperation? I would conclude from this research that the answer is no. First, it is important to note the motives behind Canada’s bellicose rhetoric and aggressive diplomacy: domestic linkages stemming from notions of Canadian pride. As both historical examples and polling data have demonstrated, Canadians respond vociferously to encroachments on their northern territories, as they perceive the Arctic to be intrinsic to, and formative, of their national identity (EKOS 2011). This renders their direction of aggression towards a defensive posture, rather than an offensive one. If anything, Canada’s rugged and deliberate reinforcing of clear-cut borders and sovereignty in its Arctic territory may serve to further stabilize the region by upholding Westphalian conceptions of interstate interactions, thereby directly answering Borgerson’s fears of a semi-anarchic polar region. Second, two of the current territorial disputes in which Canada is engaged are with the United States over a maritime border in the Beaufort Sea and control over the Northwest Passage. Given the strength of the U.S.-Canada dyad, it seems unlikely these disputes will be resolved through anything other than diplomacy. Moreover, as the domestic fervor with regards to Hans Island cools off, and with Norway and Russia already in agreement with their border, it appears that these territorial disputes—which could have at one time served as flashpoints for conflict— are quickly becoming artifacts in their respective countries’ diplomatic history.

### Arctic War D- China

#### China won’t get involved in an Arctic conflict

O’Rourke 6/15 – Specialist in Naval Affairs (Ronald, “Changes in the Arctic: Background and Issues for Congress”, 6/15/12; < http://www.fas.org/sgp/crs/misc/R41153.pdf>)//AB

Some analysts, however, believe that **China’s general approach toward the Arctic will remain decidedly low-key: “To date China has adopted a wait-and-see approach to Arctic developments, wary that active overtures would cause alarm in other countries due to China’s size and status as a rising global power**.” **China is believed to be keen on resolving through diplomacy the national interests of both littoral and nonArctic states in the high north.** Toward that end, it has sought permanent observer status on the Arctic Council.177

### Arctic War D- Russia

#### Russia needs Western technology to exploit Arctic Oil – ensures Arctic peace.

Pate 10 – US Air Force Major, Master of Arts in Security Studies (Chad P., “Easing the Arctic Tension: An Economic Solution”, writing for Naval Postgraduate School, December 2010; <http://www.hsdl.org/?view&did=11038>)//AB

With the United States emerging from a recession, there is little chance that that the military buildup outlined in NSPD-66 and the Navy Arctic Roadmap will come to fruition. Businesses in the United States stand to gain from investment overseas, yet Russia has traditionally made such investment difficult and unpredictable.49 **A key issue with Arctic oil and natural gas exploration is that Russian industry technology lags at least 10 years behind its Western counterparts**.50 **Because of this lag, Russia has in the past allowed Western corporations to share in its energy resources in exchange for technological assistance** only to mistreat the investors later on and force them out. As will be explained in Chapter III, Russia’s energy resources are dwindling so it is essential that the state bring new production locations on line as soon as possible. **Because of this need, the Russian leadership may consider reducing the barriers to investment and accept that the nation will reap fewer rewards as Western corporations share their technology.** The purpose of this thesis is to examine the **potential for establishing a capitalist peace between Russia and its Arctic neighbors against the backdrop of Russia’s declining hydrocarbon extraction capabilities**. The work’s hypothesis is that **there is little potential for conflict in the Arctic due to Russia’s inability to harvest the newly uncovered hydrocarbons on its own**. **With Western corporations possessing the necessary technology, Russian aggression in the North would likely block the inflow of FDI and harm the state’s long-term economic viability.** **If economic interconnectedness is established, the resultant capitalist peace would likely ease tensions in the region and the United States may not be forced to increase significantly its military presence in the North, thereby allaying realist concerns regarding the imbalance of Arctic military power**. **Intentional or accidental encroachment by the enlarged Russian military into sensitive U.S. areas would be less likely to escalate beyond diplomatic exchanges with the nations linked by economic bonds**. Without the ability to counter the Russian military directly should tensions escalate, relying on globalized production platforms—what Brooks argues is a “reserve stabilizer”— may offer an alternative means of maintaining the security of the United States’ northernmost border.5148

#### Russia won’t go to war with the US – it would kill their industry.

Pate 10 – US Air Force Major, Master of Arts in Security Studies (Chad P., “Easing the Arctic Tension: An Economic Solution”, writing for Naval Postgraduate School, December 2010; <http://www.hsdl.org/?view&did=11038>)//AB

In sum, interstate relationships based on economic bonds have proven to be effective deterrents to fatal conflict initiation. The strongest deterrent force occurs between dyads that experience high levels of FDI with one another. Still significant, however, is how the desire to attract FDI prevents potentially aggressive states from initiating conflict even outside of the FDI-sending and receiving relationship. The **destabilizing effect of war makes investment risky, thereby causing states not directly involved in the conflict to be reluctant to invest in such an environment**. Russia’s stock market, for example, dropped to its lowest level in two years as a result of Russia’s 2008 conflict with Georgia.47 If significant FDI is established between Russia and the United States, the potential for the nations to engage in a military dispute may be reduced. If such investment cannot be established, **Russia may still be reluctant to initiate conflict with the United States because doing so might deter other states from investing in Russia’s industry.**

#### Binding legal agreements prevent Arctic conflict – their evidence is based on a flawed assumption of Russian hostility.

Holtsmark, 09 – is the Deputy Director at the Norwegian Institute for Defense studies. (Sven G., “Towards cooperation or confrontation: Security in the High North,” Research Paper, Research Division – NATO Defense College, Rome – No. 45, February 2009 // JH)

Moreover, Western policy makers should set for themselves the ambitious goal of developing the area into a source of stability, community of interest and cooperation between Russia and the West. A recent analysis of NATO-Russia relations noted that, in order to cooperate, the two sides must shift their focus from "tactical differences" to "broader strategic aims and first-order issues.” Their first-order ambition should be to agree on "a desired end state" reflecting commonly identified shared objectives. The Arctic Ocean area, where numerous arenas for comprehensive cooperation are still open, represents a chance to put these guidelines into practice. The shared objectives in the High North must include final and permanent solutions to unresolved issues of territorial delimitation and natural resources management and exploitation. There are, in fact, several factors that contradict the often repeated pessimistic scenarios for the Arctic Ocean. As mentioned above, some of the most promising potential petroleum reserves are in areas of undisputed national jurisdiction. Even where this is not the case, there is agreement among the littoral states, including Russia, about the need for multilateral solutions to regional challenges. This includes support for UNCLOS as the overarching legal framework. The Ilulissat declaration points exactly in this direction. The long history of successful regional cooperation on resources management in the region, even between cold war foes, gives cause for optimism. Apart from defining the framework for the resolution of delimitational disputes, this approach calls for the further development of robust regimes for the handling of issues such as ecological safety and living resources management, the challenges of opening and operating new SLOCs, and the handling of security threats emanating from outside the Arctic Ocean region. The list of challenges that can only be handled through cooperation between all the Arctic states can easily be expanded. In most cases, framework regimes are already in place, so there is no need start from a "blank sheet". Alarmist scenarios are often linked to pessimistic predictions of Russian behavior, and certain aspects of Russian rhetoric and action give legitimate reasons for concern. So does the fundamental weakness of the Russian regime in terms of domestic legitimacy, and the ability and will to withstand pressures towards authoritarian solutions. Up until now, however, Russian foreign policy statements and strategy documents regularly emphasize the primary role of international law and multilateralism in international relations. Despite the harsh tone, this message was at the core of then President Putin's much-discussed Munich speech in February 2007," and less confrontationally in President Medvedev's proposal in the summer of 2008 of new European security architecture." Such statements should not be routinely dismissed as simple expressions of a fundamentally anti-American and anti-Western agenda. It may well be that Russian policy makers realize that adherence to international law and collective solutions are in fact in Russia's own vital interest. If so, this would be in line with the traditional behavior of middle-sized powers or powers with limited power projection capabilities." Even the military operation against Georgia in August 2008 does not necessarily contradict this interpretation of Russia's fundamental foreign and security policies. However controversial and possibly misguided, legal arguments have been at the forefront of Russian justifications of their actions towards Georgia. The preferred Russian comparison between Kosovo and South Ossetia is not altogether without relevance. Stating this does not imply any sympathy with Russia's instrumental use of the South Ossetia and Abkhazia conflicts, or the behavior of Russian troops in the field. However, given that the Russian interpretation of the events leading up to and following NATO's (1999) and Russia's (2008) interventions diverge substantially from the dominant Western view, and not merely for instrumental reasons, it is important to remind oneself of the importance of sometimes elusive perceptions as a key factor in state actors' policies. This being said, lingering uncertainties about the future Russian posture is one reason why there is more to High North security than creating frameworks for regional cooperation.

# \*\*\*Misc Updates\*\*\*

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### Action Now= Future Decline

#### The point of emissions reductions isn’t to cause an immediate temperature decrease- we are cutting emissions to insure we don’t pass the tipping point in the future

De Souza 11 (Mike De Souza- National political correspondent for Postmedia News focusing on energy and environment issues, October 31 2011, “Warming could be erased”, accessed via proquest)//JM

"Immediate cessation of CO2 emissions ... cannot have a large near-term effect on global temperatures," said the memorandum, drafted in April by Environment Canada scientists Greg Flato and Elizabeth Bush. "Our past emissions have essentially 'locked in' the warming experienced to date, committing future generations to a warmer world. The real issue is that ongoing emissions lead to ongoing increases in atmospheric CO2 and therefore ongoing warming." The memo was written in response to an opinion piece published in a national newspaper that cast doubt on the credibility of scientific evidence linking human activity to global warming observed in recent decades. The memo noted that there was no credible evidence supporting the arguments from the piece that are repeatedly used by climate change skeptics to discourage action in addressing pollution that largely comes from the burning of fossil fuels such as coal, oil and gas. "If the rate of warming is to be reduced, so as to avoid the 'dangerous' climate change referred to in the (international climate change) discussions, then emission reductions are required," said the memo to Environment Canada deputy minister Paul Boothe, released to Postmedia News through access to information legislation. "The warming that has been caused so far cannot be 'undone' - at least for many centuries. The point of emission reductions is to reduce further warming in the future." The memo said the opinion piece, published in the National Post by David Evans, a former consultant to the Australian government, made many statements "considered misleading" that could be refuted by a "vast body of peer-reviewed scientific literature." Some of the arguments used by Evans included claims that climate projections from the past were overstated and suggestions that any observed changes fall within the range of natural climate variability. But the Environment Canada scientists wrote that the international panel that assesses peer-reviewed climate change science has made projections since 1990 that "overlap one another and are consistent with the observed climate change that occurred after the projections were made." The scientists also slammed the climate skeptic claims that surface temperature records were distorted by the location of thermometers and a lack of satellite data, noting that researchers around the world are always required to address these issues through extensive reviews and "quality control." "The claim that estimates of global warming are significantly biased by the positioning of thermometers over hot tarmac and jet engines and decomposing sewage is without scientific basis - though it is a recurring theme in climate skeptic writings," said the memo. "It is also untrue that the climate science community does not make use of satellite-based estimates of temperature." The memo said that Evans was correct in claiming that the climate would only cool by a small fraction of a degree if emissions immediately stopped, but said that this actually justifies cutting emissions. "Rather than it being a reason not to be concerned, it is in fact the reason emissions must be reduced," said the memo, which emphasized the word "must" in italics. "It is important to recall that carbon dioxide remains in the atmosphere for many decades after it is emitted, and so continues to contribute to warming long into the future."

### Reducing Emissions Key- Sea Level Rise

#### Err on the side of caution- as long as we reduce emissions enough we can avoid the most prominent threat to adaption- sea level rise

ScienceDaily 6/24 (Website based on providing objective science, June 24 2012, “Significant Sea-Level Rise in a Two-Degree Warmer World”, http://www.sciencedaily.com/releases/2012/06/120624134955.htm)//JM

Sea levels around the world can be expected to rise by several metres in coming centuries, if global warming carries on. Even if global warming is limited to 2 degrees Celsius, global-mean sea level could continue to rise, reaching between 1.5 and 4 metres above present-day levels by the year 2300, with the best estimate being at 2.7 metres, according to a study just published in Nature Climate Change. However, emissions reductions that allow warming to drop below 1.5 degrees Celsius could limit the rise strongly. The study is the first to give a comprehensive projection for this long perspective, based on observed sea-level rise over the past millennium, as well as on scenarios for future greenhouse-gas emissions. "Sea-level rise is a hard to quantify, yet critical risk of climate change," says Michiel Schaeffer of Climate Analytics and Wageningen University, lead author of the study. "Due to the long time it takes for the world's ice and water masses to react to global warming, our emissions today determine sea levels for centuries to come." Limiting global warming could considerably reduce sea-level rise While the findings suggest that even at relatively low levels of global warming the world will have to face significant sea-level rise, the study also demonstrates the benefits of reducing greenhouse-gas emissions. Limiting global warming to below 1.5 degrees Celsius and subsequent temperature reductions could halve sea-level rise by 2300, compared to a 2-degree scenario. If temperatures are allowed to rise by 3 degrees, the expected sea-level rise could range between 2 and 5 metres, with the best estimate being at 3.5 metres. The potential impacts are significant. "As an example, for New York City it has been shown that one metre of sea level rise could raise the frequency of severe flooding from once per century to once every three years," says Stefan Rahmstorf of the Potsdam Institute for Climate Impact Research, co-author of the study. Also, low lying deltaic countries like Bangladesh and many small island states are likely to be severely affected. Sea-level rise rate defines the time for adaptation The scientists further assessed the rate of sea-level rise. The warmer the climate gets, the faster the sea level climbs. "Coastal communities have less time to adapt if sea-levels rise faster," Rahmstorf says. "In our projections, a constant level of 2-degree warming will sustain rates of sea-level rise twice as high as observed today, until well after 2300," adds Schaeffer, "but much deeper emission reductions seem able to achieve a strong slow-down, or even a stabilization of sea level over that time frame." Building on data from the past Previous multi-century projections of sea-level rise reviewed by the Intergovernmental Panel on Climate Change (IPCC) were limited to the rise caused by thermal expansion of the ocean water as it heats up, which the IPCC found could reach up to a metre by 2300. However, this estimate did not include the potentially larger effect of melting ice, and research exploring this effect has considerably advanced in the last few years. The new study is using a complementary approach, called semi-empirical, that is based on using the connection between observed temperature and sea level during past centuries in order to estimate sea-level rise for scenarios of future global warming. "Of course it remains open how far the close link between temperature and global sea level found for the past will carry on into the future," says Rahmstorf. "Despite the uncertainty we still have about future sea level, from a risk perspective our approach provides at least plausible, and relevant, estimates."