OIL AND CLIMATE CHANGE IN THE ARCTIC POWER POINT NOTES

SLIDE 2: WHAT IS CLIMATE CHANGE?

Ask students if they can name any effects of climate change.

- Global temperatures have risen 1.4°F over the last century.
- Weather: changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves.
- The ocean is a huge carbon sink, but as it absorbs more and more carbon, the pH drops, making the water more acidic. This is bad news for animals, particularly some plankton and shell-making animals, because the acidity disrupts their life processes (making shells less structurally sound, etc.).
- As the earth warms up, the ice packs at both poles are melting at increasingly rapid rates. We'll take a look at just how fast they're melting and the albedo effect in a bit.
- As the ice melts (not icebergs, but ice on land, like the Greenland ice cap), there is more water in the ocean, which causes sea levels to rise. A large portion of the human population, including us, lives in coastal areas (think of all the large cities on the coast (New York, LA, New Orleans).

SLIDE 3: CLIMATE CHANGE IN ACTION

A Way Forward: Facing Climate Change

A short film from National Geographic about the impacts of climate change with some good visuals. Stop after 5:10 (the rest talks about response and mitigation).

http://video.nationalgeographic.com/video/way-forward-climate

SLIDE 4: GLACIAL RETREAT

Along with the melting icecaps at the poles, glaciers around the world are retreating at unprecedented rates. Here we look at time-lapse photos of three different glaciers and see how they've changed. Make sure to point out the change in dates. Some aren't even that far apart. And point out the consistent physical features (mountains, ridges, etc.).

Muir Glacier, located in Glacier Bay, Alaska: 1941, 1976 (exposed rocks), 2004 lush vegetation with glacier barely visible)

Qori Kalis Glacier, located in the Andes in Peru: 1978 and 2004

McCall Glacier, located in ANWR, Alaska: 1958 and 2003

SLIDE 5: COLLAPSE OF ICE SHELF

An animation of the collapse of an ice shelf in Antarctica. Pay attention to the dates. A huge amount of ice broke off in a very short amount of time. Over 3000 square kilometers of ice 220m thick disintegrated. This means that an ice shelf comparable in size to the state of Rhode Island collapsed in a single season. This ice shelf was stable for up to 12,000 years prior to this.

SLIDE 6: DIFFERENT KINDS OF SEA ICE

However, there are different types of sea ice. This diagram has a lot going on, but start with pack and fast ice. Fast ice is ice attached (frozen) to land; this is the section on the left. This is stable and doesn't drift around, because it is anchored to the coast. Pack ice on the other hand isn't stable and is constantly drifting with the currents and wind. This means it is very dynamic. It is also not a solid block of ice. As you can see from the diagram, there are holes, such as fractures and leads, and these are constantly shifting.

Another distinction is first-year and multi-year ice. First-year sea ice has no more than one year of growth. It is ice that grows in the fall and winter but melts in the spring and summer months. Multi-year ice is older and is ice that has survived at least one melting season (at least one summer). Because of this, old ice is generally thicker than first-year sea ice and you can see this in the diagram.

SLIDE 7: SEA ICE IN THE ARCTIC 1

This picture shows the extent of sea ice in September 1980. Notice how big it is (touching most of the land around the Arctic Sea) and where it is positioned.

SLIDE 8: SEA ICE IN THE ARCTIC 2

Notice the change in the sea ice from 1980 to 2007. The second part of the slide shows the amount of ice lost in relation to the Lower 48.

- Arctic sea ice has decreased 14% since the 1970s.
- In 2012, Arctic sea ice extent hit the lowest level ever recorded, breaking the previous record set in 2007.
- By 2040, summer sea ice could be limited to the northern coast of Greenland and Canada

SLIDE 9: ICE LOSS IN 2010

In 2012, the extent of Arctic sea ice hit the lowest level ever recorded. This short animation shows the 2012 extent in relation to the historic average.

SLIDE 10: THE ALBEDO EFFECT

Shiny ice and snow reflect a higher proportion of the sun's energy into space. As the snow and ice in the Arctic continues to melt, more bare rock and water are exposed. They are darker and absorb more and more of the sun's energy. This is called the albedo effect. This is an example of a feedback loop.

SLIDE 11: POSITIVE FEEDBACK LOOP

A herd of cattle standing around grazing is calm, but once a few cattle start running, that causes other cattle to panic and start running, which eventually leads to the whole herd stampeding. This is an example of a positive feedback loop, because the more cattle that are running, the higher the panic level of the herd, which continues to increase the number running and hence the panic levels. The albedo effect can cause a positive feedback loop in which sunlight causes water to warm, which melts more ice, which exposes more water allowing more water to be heated.

SLIDE 13: EFFECTS ON CLIMATE

The Arctic is warming at a rate almost twice the global average. This means that many of the defining characteristics of the Arctic (sea ice, permafrost) will change or disappear.

- Albedo effect means there will be a positive feedback loop with loss of sea ice.
- Loss of permafrost will alter the environment (water will be able to drain more, drying out the land); also could release large amounts of methane, increasing greenhouse gases in the atmosphere.
- Shifts in precipitation and runoff could dry out some of the marshy habitat that migratory birds depend on for breeding ground.
- As some areas dry out, they are at greater risk for forest fires.

SLIDE 14: BERING SEA EXPEDITION

This is a short film about climate-driven change in the Northern Bering Sea. Some background information on the film:
"Chief scientist Jackie Grebmeier's May-June cruise aboard the USCGC HEALY looked at climate change and its impact on the local marine ecosystem, from the smallest creatures to those farther up the food chain. Also on board, and leading off our report, Perry

Pungowiyi, a Siberian Yupik who's been noticing changes in the abundance of sea-ice, and the timing of its appearance and disappearance. See a seal census, with white-clad NOAA researchers (for camouflage) jumping from ice floe to ice floe. Hear from the researchers how a changing environment impacts all the inhabitants of the narrow ocean that stretches between Alaska and Siberia, till now one of the most productive seas in the world, and a major fishery on which the USA depends. Meet the inhabitants of this aquatic "neighborhood", as Jackie describes it, and learn what makes it tick... and change."

SLIDE 15: EFFECTS ON PLANTS IN THE ARCTIC

- Longer growing season could be good, although it might allow other plants to outcompete historic Arctic plants since they no longer have that advantage.
- If winters become less severe and permafrost melts, trees could grow farther north, since the conditions preventing tall growing plants that require strong root systems would no longer exist.
- As the treeline moves north and temperatures and rainfall patterns change, the plants that are best able to survive in the Arctic region might change. This would have repercussions on animals that depend on these plants too.
- If it starts to warm earlier in the year, flowers might start blooming sooner. This would allow them more time to complete their life cycle, but if the insects they rely on for pollination are not around, this could be a major problem. Without their pollinators, plants can't reproduce.

SLIDE 16: EFFECTS ON ANIMALS IN THE ARCTIC 1

- Changing plant composition could affect herbivores that depend on those plants, forcing them to find alternate or less desirable forage.
- An extended growing season could increase access to food in the summer.
- A warmer climate increases freeze-thaw periods, potentially creating a layer of ice on top of the snow that could prevent animals from accessing their food. If food is too hard to get to, animals will expend too much energy, eventually leading to starvation.
- Migrating birds could lose their breeding grounds as the treeline moves north and permafrost melts, drying out the wetlands they depend upon.

SLIDE 17: EFFECTS ON ANIMALS IN THE ARCTIC 2

- Algae blooms during the spring provide food for small crustaceans and animal plankton, which in turn provide the basis for the enormous stocks of fish that live in Arctic seas. They are the basis for the incredible productivity for the Arctic Ocean and Bering Sea. The algae blooms along the ice edge could change as the ice retreats further inwards. Imbalances could also arise in respect to timing and locations that would be detrimental to fish stocks that are dependent on animal plankton for their food.
- Climate change would increase sea temperatures, a factor that is extremely important for the survival, spawning and distribution of young fish. Scientists anticipate that several species could migrate northwards, but it is not certain that they would be able to adapt to new areas due to the considerable variations that exist in respect to ocean depths and seabed conditions.
- Polar bears and several seal species rely on the ice. Polar bears spend most of their time out on sea ice hunting. Several seal species use the ice during their breeding season and when molting. As the ice melts, they will lose a significant amount of their habitat.

SLIDE 18: EFFECTS ON CARIBOU IN THE ARCTIC

- An extended growing season could increase access to food in the summer. However, calving is closely timed to coincide with plants at their most nutritious (just before flowering), and if the timing changes, that could affect caribou reproductive success.
- A warmer climate increases freeze-thaw periods, potentially creating a layer of ice on top of the snow that could prevent animals from accessing their food. If food is too hard to get to, animals will expend too much energy, eventually leading to starvation.
- Pests, such as mosquitoes, warble flies and nose bot flies, are a major problem for caribou. They often expend a significant amount of energy trying to avoid them, spending more time in snowfields than vegetation, where they are more bothersome. This then affects how much caribou eat, which affects their fitness and ability to survive the winter. As the climate warms, pests can

stay out longer and fewer might be killed during warmer winters.

SLIDE 19: EFFECTS ON PEOPLE IN THE ARCTIC

Arctic peoples are intimately tied to their environments through their subsistence cultures and economies.

- They depend on marine mammals, which may go extinct or change their patterns with the disappearing sea ice.
- Reindeer may change their migration and calving behavior due to changing forage availability.
- Land animals and plants may change their distribution or migration patterns, making harvesting more difficult or unreliable.
- Changing ice and snow conditions on land may make travel more difficult. For example, rivers were thoroughfares, but now they can't always trust the ice.
- Coastal people in particular are also at risk from more severe storms.

SLIDE 21: WHAT CAUSES CLIMATE CHANGE?

Can you name any human activities that might cause climate change?

Over the last 200 years in particular, human activities have released large amounts of carbon dioxide and other greenhouse gases into the atmosphere. The majority have come from burning fossil fuels to produce energy. We burn fossil fuels to heat our homes, power our cars, produce electricity and for various other reasons. Our industrial processes, such as manufacturing, as well as agricultural processes (fertilizers, etc.) also emit gases into the atmosphere. Deforestation is another cause of climate change. Forests act as a carbon sink, and as we cut more and more trees down, we lose both the carbon in those trees and their future services as a carbon sink.

Why do we care about all these gases being emitted? Something called the greenhouse effect! (see next slide)

SLIDE 22: GREENHOUSE EFFECT

Ask if anyone can describe the greenhouse effect. The idea is that greenhouse gases (carbon, methane, etc.) effectively trap heat in the atmosphere. Go through the steps with them. As sunlight comes to the Earth, the

atmosphere reflects some of it back into space. Of the rest of the sunlight that makes it through into the atmosphere, some of it is absorbed as heat by the Earth and some is reflected off the Earth. Of this reflected heat, some of it escapes out of the atmosphere into space and some is absorbed by greenhouse gases and re-emitted back to Earth, causing it to absorb more heat.

This is important, because the more greenhouse gases in the atmosphere (put there by burning fossil fuels, deforestation, etc.), the more heat is trapped, which causes the Earth to continue to warm. The greenhouse effect is natural and necessary to support life on Earth (one of the reasons that our Earth is warm enough). However, the current buildup of greenhouse gases to unprecedented levels is changing the Earth's climate and could result in numerous negative effects to ecosystems and human health and welfare.

Before transitioning to the next slide, ask them if they can name one fossil fuel that we've been talking about all year. (oil)

SLIDE 23: OIL AND THE ARCTIC

Oil! But why does oil have an impact on climate change? Because it is a fossil fuel that people burn for energy. We use it for all sorts of things, including transportation, heating, electricity, lubrication and it is a basic part in over 6000 products. Does anyone know where oil comes from? (answer on next slide)

SLIDE 24: WHERE DOES OIL COME FROM?

- Organisms living millions of years ago died and were buried under sediment at the bottom of the ocean.
- As they were buried deeper, heat and pressure changed the mud into rocks and the dead organisms into oil and natural gas.
- Some of this oil and gas was trapped under rocks and these are the oil deposits people drill into today.

SLIDE 25: DRILLING FOR OIL 1

- After selecting a site, scientists survey the area to determine its boundaries. The oil company may have to deal with legal issues such as lease agreements, titles and right-of-way accesses before they are allowed to begin the drilling process. If the site is off-shore, legal jurisdiction must also be determined (i.e., which company has the right to drill there).
- In addition to these legal issues, an environmental impact study may also

have to be conducted to determine the effects the drilling could have on the local environment and if the risks involved are acceptable.

- In order to get all the equipment to the drilling site, access roads have to be built. Equipment can also be brought in by helicopter or barge, depending on the location of the site.
- Then the land at the drilling site has to be cleared and leveled before anything can be built.

SLIDE 26: DRILLING FOR OIL 2

Once the land is ready, the oil company can start constructing the drilling infrastructure.

- Water is used for drilling, so there must be a source of water nearby. If there is no natural source, a water well has to be drilled.
- The crew then has to dig a reserve pit. This is used to dispose of rock cuttings and drilling mud produced during the drilling process. The reserve pit is lined with plastic to protect the environment. If the site is in a particularly ecologically sensitive area, such as a marsh or wilderness, these waste products have to be disposed of offsite, being trucked away instead of placed in a pit.
- Once these things have been done to finish preparing the land, the crew begins preparing the pad, by digging several holes to make way for the rig and the main hole.
- The crew then starts digging the main hole, often using a small drill truck rather than the main rig. The first part of the hole is larger and shallower than the main portion and is lined with a large-diameter conductor pipe. The crew also has to dig additional holes off to the side to temporarily store equipment.
- After this is done, the main rig equipment can be brought in and set up. Some rigs are built on ships or barges for work on water where there is no foundation to support a rig.

This picture is from Prudhoe Bay. Look at how much infrastructure is needed to drill for oil.

Now we're going to do an activity where you have to design an oil field and drill for oil in the Arctic. While you're doing this, have students think about what special problems might arise in this environment.

SLIDE 27: TRANSPORTING OIL

What are some problems that could go along with each of these methods of transportation?

Some possible answers: leaks, shipwrecks, traffic accidents, terrorism/pirates, insufficient maintenance (corrosion, etc.), rupturing pipeline/container, explosions

SLIDE 28: PROBLEMS WITH OIL IN THE ARCTIC

- Harsh winter weather requires that the equipment be specially designed to withstand the frigid temperatures. It also makes working there more difficult, which requires more incentives from the oil companies.
- Unpredictable ice and weather conditions (strong winter storms, drifting pack ice, etc.) make both drilling and transportation of oil difficult. The icepack can damage offshore facilities. Both weather and the icepack can hinder the shipment of personnel, materials, equipment and oil for long periods of time.
- There are long periods of the year where the sun doesn't come up. This makes working difficult and increases the chances of accidents.
- The Arctic is very remote. This means there is limited transportation access and long distances from manufacturing areas reduce the transportation options and increase the costs. Long distances from manufacturing areas also require equipment redundancy and a larger inventory of spare parts for backup.
- Poor soil conditions and permafrost can require additional site preparation to prevent equipment and structures from sinking into boggy areas or melting permafrost. The marshy tundra can also prevent exploration activities during the summer.

All of these are reasons why oil extraction is more difficult in the Arctic than in other regions of the world. It is also a very environmentally sensitive place. Plants and animals exploit unique niches in the Arctic and the harsh weather and short growing season mean that things could take longer to respond and bounce back from changes. So we'll look at the potential effects of both drilling and an oil spill.

SLIDE 29: IMPACTS OF DRILLING IN THE ARCTIC

- Drilling, at least in Alaska, has taken place primarily on the North Slope. This is crucial breeding ground for millions of migrating birds and several caribou herds. The massive infrastructure required for drilling decreases the

amount of habitat available for these populations.

- Caribou in particular migrate to the North Slope every year to give birth to their calves. While supporters of drilling argue that environmentally-friendly drilling infrastructure is possible, others maintain that drilling will disrupt their migration and result in a drop in births and herd size.
- The growth of infrastructure could lead to erosion and melting permafrost, which would affect the ground structure.
- Building on the tundra requires large amounts of gravel for pads, harbors and roads. This gravel is generally mined from other parts of the tundra and mountains, which creates all the problems associated with mining. Another common building technique in the Arctic is the construction of ice roads, which requires large amounts of water, thus decreasing the amount available for plants and animals.
- Oil infrastructure can result in significant damage to both benthic organisms, such as corals, and sea floor habitats from subsea infrastructure, like pipelines from offshore installations.

SLIDE 30: IMPACTS OF AN OIL SPILL IN THE ARCTIC 1

- Top predators, like cod, seals and seabirds, tend to congregate in extremely large groups during the most productive time of year. This means that a single large oil spill in the wrong place and at the wrong time of year can have very serious, population-wide impacts on seabirds, fish, and some marine mammals.
- The Arctic marine food web is based on the plankton and algae that bloom along the edges of the sea ice. If a spill were to affect these organisms, it would have repercussions throughout the food chain.
- Summer in the Arctic is short and not particularly warm. This means that animals and plants have to take advantage of this brief period of productivity. If an oil spill were to disrupt this, it could impact the ability of plants and animals to survive the winter.

SLIDE 31: VULNERABILITIES TO AN OIL SPILL

This diagram shows the various aspects of the Arctic system and the potential impacts of an oil spill.

- Starting on the coast, wetlands and coastal tundra, which are highly productive breeding and spawning areas, could be oiled and degraded, decreasing or eliminating habitat productivity.
- In the pelagic zone, which is a productive area or the marine food web, both surface and dispersed oil could affect the food web. Fish eggs and larvae are particularly sensitive.
- In the benthic habitat (seafloor), which can be important for cycling nutrients, oil could get into sediments, reducing productivity.
- Top predators are of global significance and are important for the food web. Oil can create health problems for individual animals and affect the food web.
- The sea ice, which is seasonally important for productivity and habitat for marine mammals, could be sensitive to oil, but not much research has been done.

SLIDE 32: IMPACTS OF AN OIL SPILL IN THE ARCTIC 2

Stress to the students that there is no effective method for containing and cleaning up an oil spill in ice conditions. This makes drilling and transporting oil in the Arctic extremely risky. Not only are there more conditions that could cause a spill (darkness, harsh weather, permafrost, ice, etc.), but if a spill were to happen, it could be almost impossible to clean up. Clean-up equipment and personnel would be harder and more expensive and more time-consuming to transport up to the Arctic. In addition, no one knows how to effectively clean up a spill with sea ice in the equation. Clean-up techniques are still being adjusted in more temperate waters where there have been numerous spills.

BUT (transition to final slide) even though there is no effective method, oil companies are working on figuring out better strategies to clean up a potential spill. Technology used in more temperate regions is being adapted to Arctic conditions with some changes. This is an ongoing process, but people are working to improve our capacity to prevent and clean-up a spill.

Slide 33: Potential Response Equipment

Booms are used to corral the oil, while skimmers then separate the oil from the water and allow it to be transferred to a containment ship to remove it from the area.

In-situ burning is a very effective clean-up method, but it releases toxic fumes and

chemicals and should not be used near human populations.

Icebreakers are important in the deployment of this technology. The chance of an oil spill in the Arctic happening in ice-choked or frozen waters is very high, thus necessitating the use of an icebreaking ship before any of the other equipment is used.

Remember our oil spill clean-up lab from October when you tried to clean up the water, plants and animals after an oil spill? Tomorrow we're going to use some of this technology to test our skills at cleaning up an oil spill in the Arctic.