By the middle of this century, the world will likely be home to 9 billion people and energy demand is expected to have doubled. The oil and natural gas locked beneath the seas off Alaska could be a vital part of the future energy mix. These resources must be developed responsibly. Local communities rely on this complex ecosystem for survival and the region plays a vital role in the planet’s biodiversity and climate patterns.

So before starting to explore for energy resources in the Chukchi Sea and Camden Bay in the Beaufort Sea, Shell has conducted and supported hundreds of detailed scientific studies. These build on a vast body of existing Arctic research and break new ground. Our studies bring together a wide range of experts and use advanced technologies to learn more about many aspects of the environment: from weather patterns to sea currents; from tiny seabed organisms to 100-tonne marine mammals. The results allow us to identify natural trends and the effects of climate change over time, which we share with government, academia, and others. Our findings also help us to better plan our operations, so we can reduce impact and co-exist with local subsistence communities.
“THIS IS ONE OF THE FIRST INTERDISCIPLINARY ECOSYSTEM LEVEL STUDIES THAT I KNOW OF IN THE NORTH-EASTERN CHUKCHI SEA.”
Dr. Robert Day, senior scientist at ABR Environmental Research and Services, on the Chukchi Sea Environmental Studies Programme.

A CENTURY OF RESEARCH

The Alaskan Arctic is one of the most studied regions in modern history. THOUSANDS of independent studies on Alaska’s northern coast and nearby seas have been conducted by Federal state and local government agencies, environmental organisations, industry and academic and research institutions over more than 100 years. Since 1973, the Department of the Interior’s Alaska Environmental Studies Program has spent the equivalent of $1 BILLION on research and completed over 400 studies. Today it maintains more than 45 ongoing studies and many more are planned for future years. This is the world’s most comprehensive effort to collect environmental, social and economic data for assessing the potential impact of resource development. Additionally, DOZENS of other organisations are conducting environmental research in the region. Oil and gas companies are now boosting the level of research in the specific areas where they plan to operate. In the last five years Shell alone has spent about $60 MILLION on Alaska science. Along with Statoil and ConocoPhilips, Shell funds the Chukchi Sea Environmental Studies Programme. This is the FIRST STUDY OF ITS KIND in this area, uniting experts from many fields of marine science – including physical oceanography, seabird research, plankton ecology and underwater acoustics.

As the pieces of their diverse research findings come together, these scientists are creating a detailed understanding of complex environmental interactions, such as how the effects of physical aspects like sea currents and ice affect the diverse marine life.
**SHIFTING SHORES**

**Shoreline**
The Arctic weather is changing the shape of the Alaskan coastline. This is because warmer temperatures in recent years – from natural changes and manmade CO₂ emissions – have prevented more of the sea surface from freezing. As the wind blows over these open waters, it has more space to push the water into larger waves and higher seas. The result: increasing coastal erosion.

**Chukchi Sea**
Shell data is shedding light on where – and why – specific water conditions exist. Strong, warm currents from the Pacific shoot through the Bering Strait, sweeping rich stores of nutrients through underground valleys and around shoals. These warmer water masses resist mixing with colder, more saline winter water, which sinks to the bottom beneath layers of fresh melt water.

In the warmer currents, tiny creatures called plankton create “hot spots” of feeding activity for fish, seals and surface-feeding birds. Most plankton, however, sinks to the sea floor and supports thriving communities of shellfish, worms and other bottom-dwellers that are in turn consumed by walruses, mures and other deep-diving birds. Scientists have identified certain invertebrate marine worm species for the first time in the Chukchi Sea. They have also discovered a potentially new species of shrimp-like crustaceans.

**Beaufort Sea**
Westerly winds create rich upwellings – important feeding areas for bowhead whales. Shell studies are also characterising the magnitude and frequency of ice gouges and other sea floor scour features that are associated with sea ice movement and spring breakup dynamics. This is important information for engineers who must design offshore energy facilities capable of withstanding these forces.

**On land**
Our research on land has focused in particular on identifying sensitive habitats and special areas such as caribou calving grounds. The results of these ongoing studies will allow us to build pipelines and build facilities in locations with a reduced risk of disturbing local wildlife or subsistence hunting.
WALRUS WATCH:
Fresh details on how walrus adapt to changes in the climate

- Able to tolerate up to 160 decibels of noise, it has been shown that bowheads will feed and migrate through areas of industry activity. They temporarily change course by up to 15 kilometres (nine miles) to avoid louder sounds. As a result, we shut down operations and leave the drill site in the Beaufort Sea during hunting and only resume when local people say they have caught the number of whales they need for food.

- Shell’s underwater recordings of mammal sounds have also shown that some seasonal migrants are extending their range and spending more time in the Arctic, likely due to the changing climate. Microphones have detected the presence of fin whales, humpback whales and Dall’s porpoise – along with the first evidence of a sei whale – beyond their normal range in the Chukchi.

- Since 2006 Shell has monitored marine mammals in the region and supported, for example, U.S. Fish & Wildlife Service and U.S. Geological Survey, tagging programmes that enable satellite tracking of individual walrus movements to and from their feeding grounds. Combined with visual observations, acoustic recordings and ice monitoring, these programmes have revealed how Pacific walrus are adapting to changing ice conditions.

- In the Chukchi Sea, walrus mothers, when not feeding, typically haul their bodies out onto offshore sea ice to rest and care for their young. In recent summers during periods of diminished offshore sea ice, however, walrus are hauling out by the tens of thousands along various sections of the Chukchi coastline. Our research and monitoring has helped show that during these periods walruses continue to travel regularly between offshore feeding areas and these coastal haulouts.

- Walrus tend to stampede when they are disturbed; they can even trample their pups. So, Shell worked with the U.S. Fish & Wildlife Service and U.S. Geological Survey to establish a buffer zone of 800 metres (2,600 feet) between the animals and our operations. We also station biologists and protected species observers aboard marine vessels. Who have the responsibility to order the suspension of activities if they spot walruses or other mammals nearby.

NESTING IN PEACE:
Insights into seabird migration

- Our studies have revealed more about the traditional migration routes and nesting sites of coastal and marine birds. Consequently, when we fly our planes to deliver supplies we make sure that we stay away from onshore bird colonies.

"The research in this area is critical. We are finding more species in the Northern Arctic waters than previously thought thanks to scientific studies by industry, as well as national and international science programmes."

Dr. Jacqueline Gredmeier, U.S representative to the International Arctic Science Committee.
ARCTIC SPIES: USING TECHNOLOGY TO FIND OUT MORE ABOUT ARCTIC LIFE

- **Quieter surveillance:**
  Unmanned aerial drones may be used in future to monitor seals, whales, walrus and polar bears. Shell scientists are testing these small, remotely operated aircraft, which cruise at an altitude of 450 metres (1,500 feet) or less without disturbing animals. They can be launched from vessels or from land and fly in bad weather.

- **Listening to marine mammals:**
  Microphones arrayed across the seabed capture acoustic recordings of whale songs and the sounds of other mammals, providing details about populations and migration routes.

- **Cool vibrations:**
  Shell is also using technology to help reduce sound from our operations. For example, we have installed improved engine mounts on our new vessels. Their special material helps prevent engine vibrations from travelling to the hull and into the water.

- **Blowing bubbles:**
  Could a curtain of bubbles be used to help muffle sound? Shell engineers think so. They are investigating technology to create the bubbles by pushing air through small holes in underwater pipes and have successfully tested bubble curtains made from tyres mounted on a frame below the sea’s surface.

- **Current knowledge:**
  Oceanographic moorings are anchored to the seabed by cables and hold instruments that measure water salinity, temperature, currents and the amount of chlorophyll – an indicator of life. Weather buoys are also attached to the ocean floor to measure sea surface weather, such as wind speed and air temperature, as well as ocean conditions like waves and currents. Some buoys are placed on the ice to measure ice movement. These can also be used as monitoring devices to track any oil spill on or under the ice. These kinds of instruments allow scientists to better understand how physical forces interact to create diverse marine habitats – and why certain types of creatures live there.

“OUR UNDERSTANDING OF THE NATURAL DYNAMICS OF THESE ECOSYSTEMS ALLOWS US TO PLAN OUR DRILLING OPERATIONS TO MINIMISE ANY IMPACT.”

Erling Westlien, Shell Senior Environmental Engineer
SHARING FINDINGS WITH GOVERNMENT, ACADEMICS AND LOCAL COMMUNITIES

- A partnership with the US National Oceanic and Atmospheric Administration (NOAA) combines the rich data we gather around our drill sites with NOAA’s scientific expertise on weather, climate, oceans, and fisheries management. This helps NOAA to monitor climate change and improve their Arctic weather forecasting. Governments can also use the data to establish effective marine management policies.

- We are making our research findings publicly available to industry partners, government agencies, academic institutions and subsistence communities. Our scientists have presented their findings through numerous international conferences and scientific journals as well as village community meetings. They also serve on science advisory boards and committees at all levels. By developing collaborative networks, we create the critical mass needed to achieve common goals.

- Shell provides up to $5 million each year to local communities through an agreement with the North Slope Borough. This helps ensure a collaborative approach to scientific research and independent review of studies, regulatory documents, and exploration and development plans.