COVE
Workforce Initiative

WAVE OF THE FUTURE

CANADA'S SUSTAINABLE BLUE ECONOMY

Written by Dr. Sherry Scully and Anna Naylor
Centre for Ocean Ventures and Entrepreneurship

About COVE:

COVE is a world-class facility for applied innovation in the ocean sector and the only such hub of its kind in the world where start-up companies, small and medium sized enterprises, large firms and post-secondary expertise are housed together developing ocean technology. COVE Workforce Initiative focuses on workforce development and engagement in Ocean Industries where youth and teacher engagement is a primary focus. COVE brings together people, ideas, industry and research to help our community and members work in new ways. Together, we are a catalyst in creating the world's next practical, commercial and revolutionary ocean tech advances. Irving Shipbuilding, as part of its Value Proposition commitments under the National Shipbuilding Strategy (NSS), has invested over $6 million in COVE to support development of the programs and operations. Learn more about COVE, our projects and our members at **coveocean.com**

IRVING

Irving Shipbuilding, Inc.

COVE
centre for ocean ventures & entrepreneurship

COVE WORKFORCE INITIATIVE - BLUE ECONOMY TEACHING RESOURCE
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DEDICATION

For his unlimited energy and willingness to explore a new idea; for his contagious passion for the ocean and for all the cool technologies and toys we use to explore and enjoy it; and for his vision in making COVE what it is today – we dedicate this book to our out-going CEO, Jim Hanlon.

As you sail into your next adventure, 'may the wind be always at your back', and your friends be always by your side.

Sherry and Anna

Jim Hanlon, CEO of COVE

As the son of a navy commander, I developed a curiosity for the ocean from a very young age. When I was just 5 or 6, we were living in Victoria, BC, where my father was stationed, and he took me down to the port and showed me a jet-powered catamaran! It was amazing – and my attention was grabbed. I eventually became an electrical engineer, and while I could work in any industry, the ocean was where I saw the most interesting opportunities. For years I lived and worked around other ocean tech entrepreneurs, and eventually I bought my first ocean tech business in my late 30's. Now, at COVE, I help other ocean entrepreneurs to start and build their businesses. I still find it fascinating – this is an industry for the curious and inventive – it's an industry where people with many different skills can come together because the issues and opportunities of the ocean are so intertwined, so untouched compared with other industries. And COVE is a place where other ocean entrepreneurs come to bring their ideas to life.

WAVE OF THE FUTURE

CANADA'S SUSTAINABLE BLUE ECONOMY

Focus on the Blue Economy

Blue Careers

Blue Activities

QUIZ YOURSELF

HOW MUCH DO YOU ALREADY KNOW ABOUT THE BLUE ECONOMY?

1. Canada is leading the way in the blue economy because;

- ☐ a. we have so many educated people working in the ocean industry;
- ☐ b. we already have leading ocean technology companies across Canada
- ☐ c. we are focused on a Blue Economy that is sustainable
- ☐ d. all of the above

2. True or False; We have only explored about 4% of the ocean.

- ○ T ○ F

3. Aquaculture is;

- ☐ a. farming seafood in the ocean
- ☐ b. farming fish in pens on land
- ☐ c. farming seaweed and other water plants
- ☐ d. all of the above

4. True or False; Salmon can be farmed in pens in the ocean or on land.

- ○ T ○ F

5. Most of the world's poorest people get their animal-based protein from;

- ☐ a. Beef
- ☐ b. Chicken
- ☐ c. Pork
- ☐ d. Seafood

6. The blue economy means;

- ☐ a. money we have taken from the sea (i.e. old coins, jewels)
- ☐ b. an underground economy involving pirates and explorers
- ☐ c. all industries that happen on, in, from or because of the ocean
- ☐ d. how sad we feel when the economy isn't good

7. The blue economy includes;

- ☐ a. traditional fishing and ship building only
- ☐ b. dozens of industries, including fishing, shipbuilding, boat building, energy, defense, ocean technology, marine tourism, and others
- ☐ c. only industries that take resources from the ocean
- ☐ d. only industries that work to keep the ocean clean and secure

8. Algae can be cultivated (grown);

- ☐ a. to clean a fish tank
- ☐ b. for protein and for fuel
- ☐ c. to prevent fish from getting sunburns

9. True or False; We can harness the renewable energy of the waves, the wind and the tides to convert into electricity.

- ○ T ○ F

10. True or False; To be involved in the blue economy you must be near the ocean.

- ○ T ○ F

Check your answers:

DISCOVERING THE BLUE ECONOMY

1

HOW I SEA THINGS...

- Haley Scully-Maloney, 14

Some people are drawn to mountains, to grasslands, to land in general. Me, I'm drawn to the ocean, I always have been. It's calm, sitting at the front of the boat and feeling the salt-water splashing up on your legs. Falling asleep, feeling the boat rocking back and forth under you. Even the rain feels different on the sea.

THE BLUE ECONOMY, THEN...

The blue economy refers to how people make a living from the ocean. For example; for thousands of years people have been fishing and trading resources from, and on, the ocean. Indeed, in some early and Indigenous cultures, the first currency (*money*) was actually shells – the rarer or more beautiful the shell, the more one could trade it for. Early industries quickly developed across the globe by people trading and selling fish and seafood, and also salt that was harvested from the sea.

Present-day fisherman, Burma

Yokohama Foreigners in the Sitting Room of a Merchant Ship, 1861. Metropolitan Museum of Art Archive

Present-day Floating Market, South Borneo

Illustration of traditional Inuit canoe

The ocean became the highway for trading and selling these and other goods like spices, fruit, grain, textiles (*furs, cotton and silk cloth*), and other valuables like gold and silver, which created other ocean industries like boat and ship building (*because merchants were good at buying and selling, but not so good at building their own vessels*).

Historic pirate ship

Present-day Coast Guard. canada.ca

Where there were merchants, there were pirates who wanted to steal those goods, and this created a defense industry of navies and coast guards who work to protect the industries at sea.

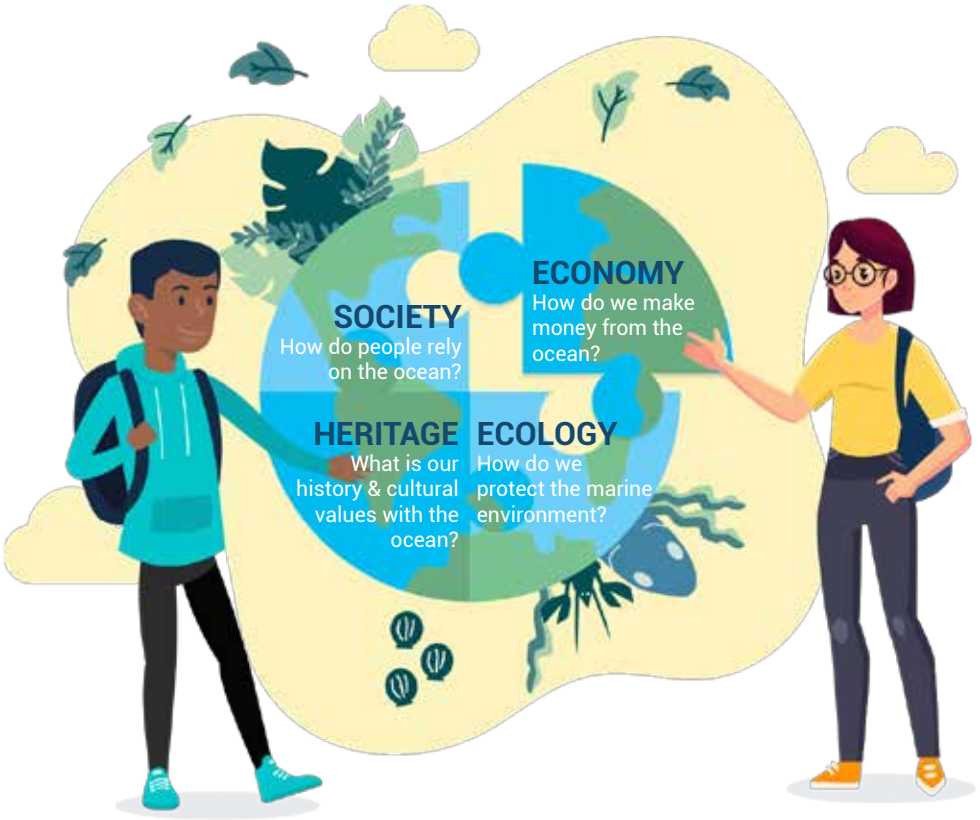
And where ships allowed people to explore new parts of the world, there were inevitably greedy kings and queens who wanted to conquer those new lands and claim them for themselves, which creates more demand for navies and armies, and for the weapons and resources they use.

Depiction of Early European conquerors. Universal History Archive/Universal Images Group/Getty Images

... AND NOW

If I asked you what the Blue Economy is today, the first thought that probably comes to mind is still – catching and selling fish. And you would be partly correct. But the Ocean Economy is more than that. It is all of the industries that work in, on, and around the ocean, that use the ocean's resources, or that explore and study the ocean.

In these pages you will learn more about these different industries and how they relate to your own life. You will learn about some of the risks and threats to the ocean that happen when we build industries in and around it. And, you will learn about how industry is working to help protect the ocean and build a sustainable blue economy – and how you can too!

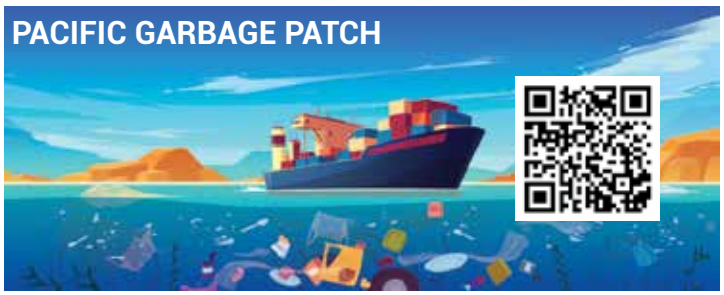


WHAT ON EARTH IS A SUSTAINABLE BLUE ECONOMY?

Before we answer that question, let's start with two quick but important facts:

1. There is just one ocean. We have different names for the ocean in different places – Atlantic, Pacific, Indian, Arctic – sometime we even call it the Sea – the Mediterranean, the Caribbean, the North, the Baltic, and the Dead Seas – but no matter how we refer to it – its all the same body of water.

That means that what happens to the ocean far across the earth matters to us here. And, what we do with the ocean here, matters everywhere else too.



These two facts are important to understand what it means to have a sustainable Blue Economy, because they remind us that we all share the ocean, we all rely on the ocean and we must all work to preserve the ocean so it will be a healthy and bountiful resource into the future.

2. No matter how close or far you are from the ocean, you interact with it in a few important ways every single day.

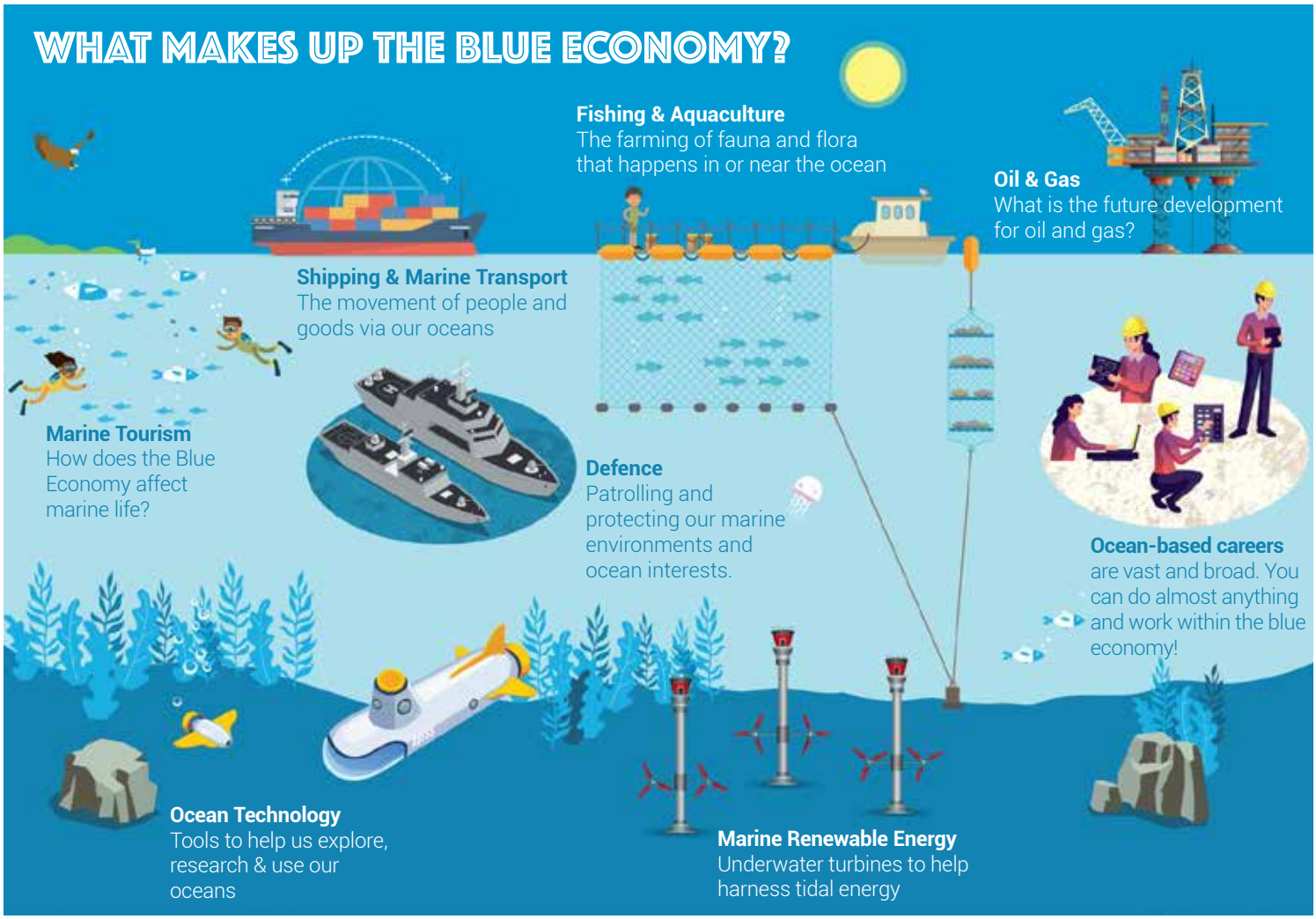
Every other breath you take comes from the ocean (that's right – it's not just trees that produce the oxygen we breathe – the ocean does that too).

And nearly everything you wear, eat, or use has spent time traveling to you on the ocean. Your phone or tablet, your running shoes, your t-shirt – if you check the labels you will see they were probably made in a country far from you and before you took them home from a store, they were loaded onto a cargo ship and sailed the great sea.

Where does our "stuff" come from?

Today, we have a better understanding of the importance of the ocean, and of our dependence on it. Which definition seems to fit today's Sustainable Blue Economy?

1. Making money by taking and trading resources from the ocean.
2. Making money by buying and selling things from the ocean with people across the globe.
3. Using information and technology to sustainably harvest the ocean's resources, and finding ways to interact with the ocean that will have the least impact on the water and the living things that call it home.




Forestry Industry


Agricultural Industry


Renewable Energy Industry

WHY DOES A SUSTAINABLE BLUE ECONOMY MATTER?

Sustainable means using something carefully so that it continues to be healthy, is able to replace itself, and can be used well into the future.

In the Forestry Industry, we talk about sustainable forestry which means planting and nurturing new trees to replace the ones we cut down.

In the Agriculture Industry, (*farming on land*), sustainable farming means putting good nutrients back into the soil (*and not putting dangerous chemicals into it*) so that the soil is healthy and can continue to grow good food.

In the Energy Industry, sustainable energy is produced from things like the sun (*solar*), the wind, or moving water (*hydroelectricity*) that are renewable (*they don't run out*) and that don't produce pollution.

THINKING GLOBALLY

Did you know that a sustainable blue economy can help us feed and provide energy to a growing world. It can help us travel and transport goods cheaply and safely across the globe, and connect us as global citizens.

SUSTAINABLE DEVELOPMENT GOALS

And we can continue to appreciate the beauty and majesty of the great ocean, while also exploring its hidden mysteries, as technology allows us to peer into the deep.

INNOVATIONS IN CANADA

Ocean Wise Ocean scientists, like zoologists and marine biologists, work at Ocean Wise and understand the importance of sustainable seafood. More than a billion people around the world depend on seafood as their primary source of protein! But overfishing has reduced the ocean's fish stocks, meaning that roughly 90 percent of the world's fish stocks are now fully fished or over-fished (*UN's Food and Agriculture Organization - FAO*).

Citizen science abundance surveys using prawn traps in the arctic. / ocean.org

The scientists at Ocean Wise recommend sustainable seafoods that are abundant and resilient to overfishing, and that are well-managed, meaning they're not over-fished, they aren't harvested in a way that damages the marine environment or other marine species. The work of these ocean scientists helps to relieve the pressure on over-fished species and ensures that we will be able to continue to enjoy seafood for generations to come.

Howe Sound Research Team gets ready for a weekly underwater biodiversity survey. Photo: ocean.org

Dr. Peter Ross and his team analyzing microplastics found in the water and in the stomachs of popular seafood species. / ocean.org

Here are some things you can do to get involved in the Blue Economy. *Which ones are you already doing? Check all that apply.*

- ☐ Learn more about the ocean and the creatures who live there.
- ☐ Dispose of garbage and recycling carefully so it doesn't end up in any waterways or the ocean.
- ☐ Be thoughtful about what you buy and use so you contribute to less waste.
- ☐ Participate in beach, lake and river cleanups.
- ☐ Learn more about interesting jobs and technology in the blue economy.
- ☐ Be an ocean champion (help others learn more about the ocean). Participate in **citizen science projects**.
- ☐ Join an ocean technology or shipbuilding summer camp to experience these industries first-hand
- ☐ Take a trip to a lake, pond, river or coastline to explore and see what you can see – get your hands – and your feet – wet!
- ☐ Take a virtual reality dive into the ocean by visiting **Ocean School**

HOW I SEA THINGS...

Photo credit: Nova Scotia Sea School, 7-day Coastal Sailing Expedition

- Ellie O'Driscoll, age 17

The ocean has always been my safe space; a place that grounds me in my life and myself. I love it's beauty and contrast. The way it can go so quickly from wild waves and stormy weather, to a peaceful calm, the warmth of the sun glowing on the surface of the water. To me, the salty air and crash of waves brings a feeling of freedom and deep appreciation for nature and the world around me.

The voice of the sea speaks to the soul

Did you know that our brains are wired to feel a bond with nature and the other living things that share our planet? Science has shown that when we are walking in a forest, or wander along a beach, our brains relax, our heartbeat slows, our mood improves, and our thoughts become more creative and optimistic! Way back in 1984, Edward O. Wilson, a Harvard University biologist, described this as "biophilia" – to describe our innate love of natural settings.

ACTIVITY: HOW DO YOU SEA THINGS...?

The ocean has inspired thousands of songs and poems. Write your own original 'How I sea things..." narrative like the one above, or a poem or song about a memorable experience you had involving the ocean or another natural waterway. Share it with us* **on Instagram** Follow and tag us @cove_workforce and use the hashtag #COVEWI in your description.

**(Remember to get your parent's permission before sharing your work or photos with us).*

FEEDING THE WORLD WITH THE BLUE ECONOMY

2

HOW I SEA THINGS...

- Shelton Nipisar- 2019 SOI Arctic Expedition

My community of Arviat, Nunavut is on the shoreline, so you could just walk there anytime. Some of my best memories are tied to the ocean, both at home and with Students on Ice. I've grown up watching the sunset over the ocean with my friends and family. One of my favorite memories is fishing with my brother. On the Students on Ice expedition we got to see icebergs and they were huge! We saw so many of them.

FILLING OUR PLATES WITH THE OCEAN'S BLUE BOUNTY

Do you ever worry about whether or not you will be able to eat today? Many people in the world worry about this every day[1] Food security is defined by having access to enough food, with variety and quality for good nutrition. Here's a way to think about the different levels of food security;

- **No food security** - may count on one meal a week, but may be poor quality and no choice in what it is
- **Limited food security** - can count on one meal a day, but the quality and variety may not always be great
- **Moderate food security** - can count on three meals a day with a fair amount of choice, but the quality and variety may not be great
- **Total food security** - can eat any kind of food, any time of the day, no concern for where next meal will come from. There will be plenty of variety and options for good quality food – though people need to make good choices to be well-nourished.

Where does the world get most of its protein from?

Protein #1

Protein #2

Protein #3

Protein #4

Protein #5

1. FAO (2019). Food and Agriculture Organization of the United Nations. The state of food security and nutrition in the world. http://www.fao.org/state-of-food-security-nutrition

If we look at what it takes to raise a pound of animal-based protein, we see that not all proteins are created equal. Conversion ratios tell us how much feed it takes to raise a pound of each type of protein:

CONVERSION RATIO - FEED : ONE POUND PROTEIN		
	**1 : 1**	**Fish and shellfish** *Some species of seaweed and micro-algae are known to contain protein levels similar to those of traditional protein sources, such as meat, egg, soybean & milk*
	**1.7 : 1**	**Chickens**
	**2.9 : 1**	**Hogs/pigs (pork)**
	**6.8: 1**	**Cattle (beef)**

This means that, when it comes to providing sources of animal protein to the world, that fish and shellfish is our most efficient option – almost every ounce of food they are fed is converted into flesh that can be eaten or used.

Some types of seaweed and micro-algae have nearly as much protein as eggs, milk, and meat.

Did you know that 1/3 of all food that is produced for people to eat is lost or wasted?!

Something to consider: Why do you think fish and shellfish have such good feed conversion ratios? *Hint: it has to do with the environment they live in.*

One of these answers is right. Which one makes the most sense? **Fish have the most efficient conversion ratio because of**;

A. Gravity and Thermodynamics (how the fish keeps its body the right temperature).

B. The salinity (saltiness) of the ocean.

It might surprise you that the answer is A! The water environment that fish live in helps to regulate their temperature, so they don't need to use their own energy to keep warm. Plus, the pull of gravity is countered by the push of buoyancy (what makes us float), and this means that unlike land-based, standing animals, they use very little energy to move or stay in place.

Shoal of fish

What is food security[2]?

Many of us in Canada don't ever need to think about whether or not we will have reliable access to enough affordable, safe, high quality, nutritious food. Compared to many countries, we are a food secure nation. But many other countries around the world are not.

ACTIVITY: FOOD SECURITY

More people around the world are going hungry. There are many global pressures that are making it difficult for people to have access to affordable, good quality food. Some of these pressures include; growing populations, changing weather patterns and storms that damage crops, wasting food, growing crops that can't be eaten (like tobacco), and increasing poverty making it hard for some to afford good food.

Think about what you can do in your home, school or community to help with the problem of food security. Create a poster or pictogram, using the computer, or using paper, cardboard or a chalkboard, to show your ideas. You can share your pictogram with us **on Instagram:** instagram.com/cove_workforce

Scan this QR code to learn more about the UN's sustainable development goals related to food security.

2. Click on this link to see some stats on Global Food Security http://www.fao.org/state-of-food-security-nutrition.

WHAT TRADITIONAL KNOWLEDGE CAN TEACH US

Around the world, many Indigenous cultures value sharing food, and value using food sources in completely. This helps to ensure that everyone gets enough, and that they throw away as little as possible. In traditional communities, it is believed that the tribe is healthy only if everyone is healthy!

Indigenous Perspectives on Farming the Ocean

Aquaculture is not a new idea. In traditional cultures around the world, people have been raising and cultivating freshwater and seafood in water-based or land-based farms for hundreds of years. What's new, is how we use technology and western science to become more efficient and careful about how we practice aquaculture.

In Canada, we can learn from practices of our coastal Indigenous Peoples, about how to respectfully, and sustainably, harvest from the ocean. Herring eggs have been a traditional food and source of nutrition for many coastal First Nations for hundreds of years. These Indigenous communities have suspended hemlock or cedar branches in the water near herring spawning grounds. The herring eggs are deposited onto the branches where they can then be lifted and the herring roe peeled off. Cedar branches might not be advanced technology, but it shows how resourceful people can be. Those who harvest the herring eggs know to take some, but not all – it is a lesson for all of us to respect nature and help keep fish stocks balanced. Sustainable practices like this method will help ensure the food source is available for the future as well.

Tla'amin community members harvesting herring eggs in Sliammon, BC. Photo: Roy Francis, 2014 / pacificherring.org

Oolichans – the Saviour fish

- Nicole Morvan, Nisga'a Fish & Wildlife

The oolichan is a fish of many names: eulachon, ooligan, hooligan. It is sometimes called candlefish because it is so high in oil content that when dried it can be fitted with a wick and used as a candle. To scientists it is Thaleichthys pacificus. To the Nisga'a it is saak, or the saviour fish.

For thousands of years, the Nisga'a people have harvested oolichan from K'alii-Aksim Lisims, the Nass River. It is their saviour fish, its arrival signaling winter is over and the season of harvest has begun. Both the fish and the oil produced from processing it (t'ilx in Nisga'a) were valuable trading commodities between First Nations communities. Across the pacific northwest, "grease trails" formed where First Nations travelled, carrying their bentwood boxes of t'ilx for trade with other communities, making it one of the earliest examples of what today is referred to as the blue economy.

These tiny but important fish are a good reminder from Indigenous communities, that the small fish matter – perhaps even more than the big fish (*like salmon and tuna and cod*) that we often think of when we talk about food from the ocean.

Nisga'a fishers harvest oolichan through the ice at Fishery Bay. Photo: Nicole Morven.

HOW SCIENCE AND TECHNOLOGY HELP THE BLUE ECONOMY

- **Remote sensing technology** is used to know how many fish are in the ocean (stock management) so the fishing industry can practice more sustainable fishing and harvesting of wild fish, seafood and sea-plants and avoid over-fishing. Fishtags can also be attached to fish, sea turtles or sea mammals to track where they go and learn more about where they spend their time.

Aquapod: offshore pen for remote, offshore aquaculture / innovasea.com

- **Sensors and cameras** are being developed to use in aquaculture to monitor fish and lobster traps to alert the owner when a lobster has been caught (so they don't waste time and gas boating out to empty traps)

Aquaculture monitoring: Boating to check lobster traps.

- Research helps to develop **better feed for the fish** to keep them healthier and to reduce effluent;

Research & technology creating better fish feed / Northeast Nutrition

- **Deep Trekker remotely operated vehicles (ROV)** are swimming robots that help fish farmers get a look at things underwater. Fish farmers are using them to look at their fish, their nets and anything else they would normally have to scuba dive to see. Scuba diving can be dangerous and is very expensive. Deep Trekker ROVs are really easy and fun to operate. Would you like to pilot one?

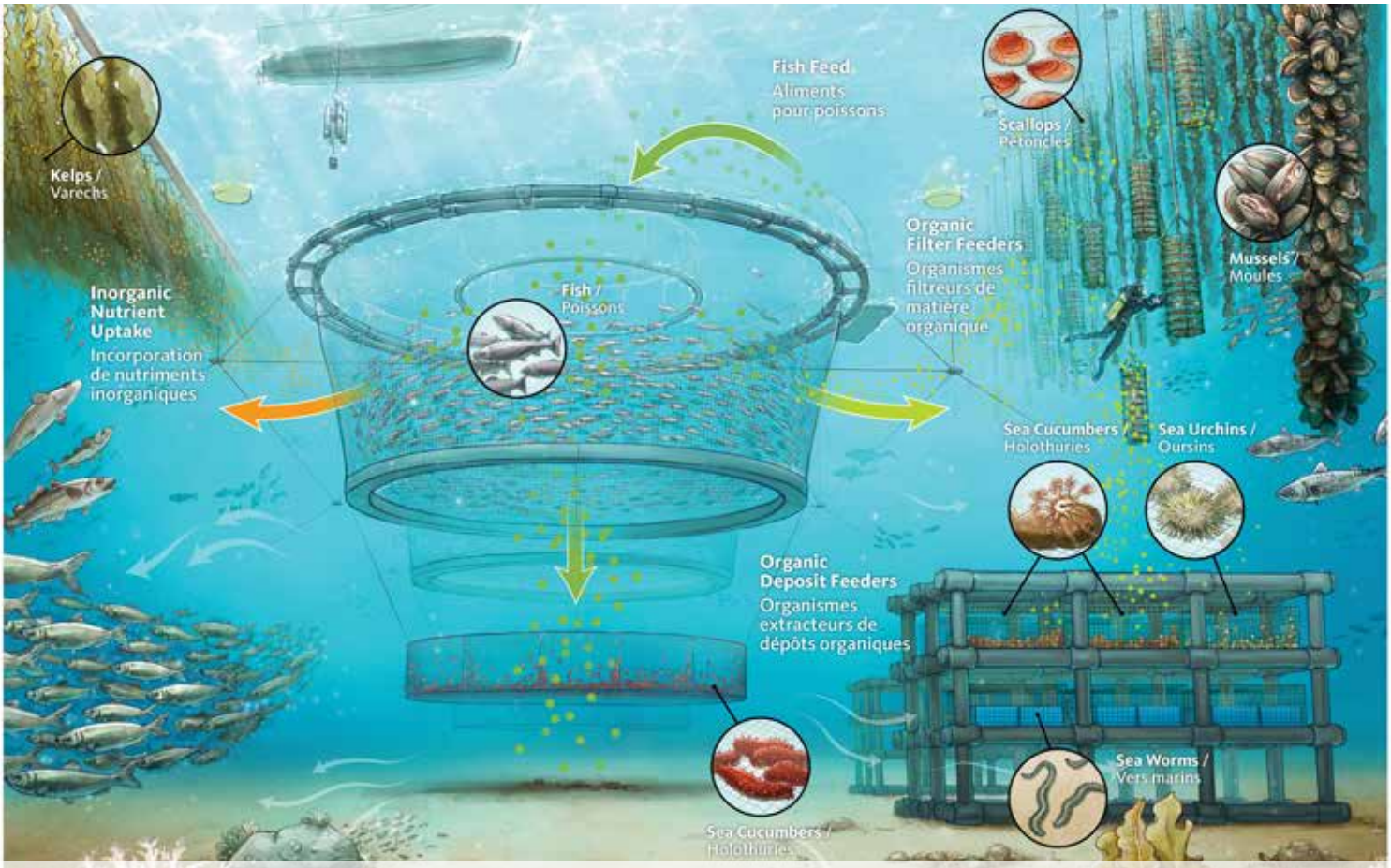
Deep Trekker ROV / deeptrekker.com

- Research has shown that using far **offshore pens** in aquaculture can allow for better flow of the water to naturally clean up the fish poop and effluent and circulate clean water. It also keeps the beaches and seasides clean and free for other uses like swimming and boating.

Offshore pens

INNOVATIONS IN CANADA

Integrated Multi-trophic Aquaculture[3] (IMTA) Wow – that's a fancy term that simply means **farming species together that are from the same food chain.** Researchers and aquaculture technicians are developing more sustainable aquaculture that is based on the idea of closed-loop farming. In the water, it means farming species in combinations that help each other to grow and to keep their environment in balance. The species that are grown together are decided by normal food chains. One species provides food or benefit for another. For example; fish, algae, oysters. The farmer feeds the salmon, the algae consume the fish waste, the oysters are filter feeders that eat the algae and keep the water environment clean.



Conceptual model for an IMTA system. Diagram courtesy of Fisheries and Oceans Canada

In Canada, IMTA is still being researched because, while it's a great idea, it is not easy to keep the system in perfect balance. The systems need enough of each species to keep the water clean and to keep each thing fed – but small changes (*like temperature, rain, and growth*) can throw it out of balance.

Here's a cool video that can tell you more about IMTA, and why it's an industry for the future.

Aquaculture at Dalhousie University, Halifax N.S.

3. https://www.dfo-mpo.gc.ca/videos/imta-amti-eng.html

SEAWEED EXTRACTS ARE GOOD FOR CROPS, ANIMALS, PEOPLE AND THE ENVIRONMENT

Contributed by Acadian Seaplants

Seaweeds help to feed the word population not only by providing food and shelter for sea creatures, but by contributing feed ingredients for production animals and pets as well as food and health ingredients for people. Did you know that seaweeds help farmers produce more food in a sustainable way?

The seaweed species that Acadian Seaplants uses to make products for crops is called Ascophyllum nodosum, but you can also call it rockweed. I am sure you have seen it floating in the Atlantic Ocean. It has bladders or little balloons that help it float.

It grows in the part of the ocean that is uncovered during low tide – it is called the intertidal zone. So, during low tide the seaweed is exposed to freezing air temperatures in the winter and scorching-hot temperatures in the summer. And it is covered by cold and salty ocean water during high tide. The seaweed has adapted to these difficult conditions through evolution. And scientists observed that the seaweed's various compounds that help it grow under such challenging conditions also help land plants grow larger and stronger.

Simply put, Acadian Seaplants takes out the content of the seaweed cells and makes it into a product sprayed on crops. After crops have been sprayed with the seaweed extract, they grow better and produce more food for humans to eat. This is how seaweeds help to feed us.

image:freepik.com

But also, plants that are larger and produce more fruits or vegetables will use up more fertilizer from the soil. This helps the environment. This way there is less unused fertilizer that could be washed out of the soil and get into ground water, rivers and oceans and end up hurting the environment. This is how seaweeds help the environment.

Acadian Seaplants harvests the seaweed in a sustainable way to make sure there will always be plenty of it left! This is how we contribute to a sustainable blue economy.

Detail of one of rockweed (ascophyllum nodosum) cultivated by Acadian Seaplants.

DESIGN CHALLENGE

Integrated Multi-trophic aquaculture is sometimes referred to as 'farming a plateful' – you can get a whole, healthy meal from one small farm. Now that's sustainable thinking!

Think about some of the popular fish and seafood (*or freshwater*) products that we eat and use. Design your own example of a multi-trophic aquaculture system.

- Include at least three different species that are part of a natural food chain (*may include fish, shellfish, sea plants, bivalves*).
- Do some research to find out what species are part of the same food-chain, and what species help to keep the environment in balance.
- You can decide how to represent your IMTA. (*Hint: you could create a 3D paper terrarium in a shoe box, you could use clay figures in a big plastic pop bottle, you could draw or paint it on paper or on an old cereal box, or you could do your illustration on a computer.*) Take a picture of your work and share it with us **on Instagram** - Follow and tag us @cove_workforce and use the hashtag #COVEWI in your description.

CAREER PROFILE: CHEF WILL LEW

My journey started when I was very young, at the Vancouver Aquarium. I went there almost every week with my family and learned about many creatures and habitats that exist in our diverse world. I would go to bed dreaming about whales, sharks, and jellyfish. As I grew up, I discovered many passions like playing the violin, music, drawing, painting, and sports, and on weekends I would cook 10-course meals with my grandfather who was a chef. These were my unique passions. Eventually I made it to University where I got a degree in Animal Biology. ***So how does one find their dream job connecting all their unique passions?***

For me, I started washing dishes at a restaurant. Soon, I discovered that I could combine my interest in creating culinary art, teaching and inspiring others about the science of the ingredients. While working my way up to become a chef, the Vancouver Aquarium created Ocean Wise which was a resource of research and education that helped chefs and consumers learn about the impact of humans on the food chain. Every one of our decisions, big or small, has a direct relation

to how we treat and respect our ocean animals and environments. I was inspired to use my voice and decisions as a chef to tell creatives stories through food. Not all sea life is the same - every creature has a purpose and a story. I want to preserve these animals and habitats and their stories for generations to come. And, I want people to appreciate the bounty of the ocean through the stories I tell with creative and artistic food. Together, we can inspire others to understand the importance of sustainability

ACTIVITY:

Are you a budding chef? Tag us on **Instagram @cove_workforce** in a photo of a beautiful plateful that you cook with your family, that uses sustainable seafood.

FISHING INDUSTRY: CATCHING FISH IN THE WILD

People have been catching and eating fish from the lakes and oceans for hundreds of thousands of years. The ocean is so huge, it seemed it would never run out of fish. But there are so many people on the earth now, who want and need fish and seafood to survive, that we need to find a more sustainable way to catch fish in the wild.

'Ghost equipment' means the nets and other fishing gear that are lost or thrown out into the ocean and become garbage.

MISTAKES:
- over-fishing
- fishing endangered species
- thinking there is an endless supply
- wasteful techniques (blasting)
- huge fishing boats (leave nothing for small companies or individuals to catch)

CLICK for more mistakes ;(

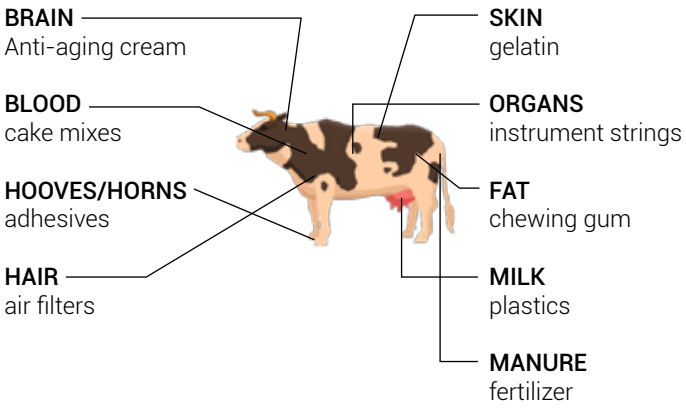
IMPROVEMENTS:
- better catch limits to manage stocks
- enforcing no fishing laws on at-risk species
- researching stock for better information
- making wasteful techniques illegal

CLICK for more improvements! :D

'By-catch' means the fish and sea-life that are caught by accident. They are usually thrown out as 'waste'

Watch this cool video to learn how we're using technology to make improvements!

DOING MORE WITH LESS!



We can make better use of what we already harvest from the ocean too– do more with less! Instead of throwing away many parts of the fish or shellfish, we can use their by-products (*like their shells, skin, scales, fat, and other flesh*) to make other useful things.

What in the world are they doing?!

The Icelandic Ocean Cluster[4] is focused on the future of the ocean. They've figured out how to 'do more with less' meaning that, instead of taking more fish out of the ocean, use more of the fish that they are already catching. Believe it or not, we only use about 40% of the fish that we catch – the rest gets thrown away. But in Iceland, they've figured out how to make use of 100% of the fish, turning the by-products (*what used to be waste*) into new, useful and high-value products.

Go into a browser and search 'what can be made with fish by-products'? Create your own illustration to show some of the many uses of fish by-products. **Share your image with us on Instagram**. Remember to tag us @cove_workforce

An Icelandic company called Atlantic Leather[5] is making fashionable and exotic leather out of a surprising source – fish skins!! The fish leather is made from salmon, perch, wolffish and cod. They are taking by-products, or the parts of the fish that would normally be thrown out as waste, and turning it into something beautiful that they can sell. This is economy and ecology acting together. Atlantic Leather is doing more, with less! But this isn't a new innovation – it's actually an old one. The idea came from early Icelanders who made their shoes from wolffish skin! What's old is new again!

"The key is simply to uncover value in waste."

— Gunter Pauli

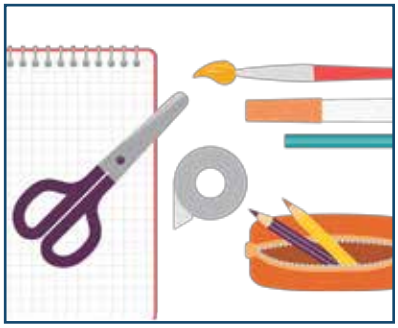
The Blue Economy 3.0: The Marriage of Science, Innovation and Entrepreneurship Creates a New Business Model That Transforms Society

4 http://www.sjavarklasinn.is/en/about/
5 http://www.atlanticleather.is/

DESIGN CHALLENGE

In the theme of doing more with less, what could you design using beautiful junk?! Have a look through your recycling for inspiration, and using the clean plastic, paper, aluminum foil, cardboard, etc. design a fashion item, making full use of the materials at hand.

You may want to design a purse, backpack, shoes, boots, hat, jewelry or clothing. **Share a picture of your creation with us on Instagram**. Remember to tag us @cove_workforce



INNOVATIONS IN CANADA

Marc d'Entremont, Pombcoup Technologies

"Today, the way we catch fish is very hurtful to the bottom of the sea. There is a large net that the boat pulls, the large net also drags on the bottom of the ocean destroying everything in its path including important corals that create a home for all the fish! Without these homes, the fish will struggle to find food to survive! My company has created a new net that will float above the seabed so it will not disturb the important homes and food source for the fish! I love being an entrepreneur because it gives me the freedom to be creative and to help make a better world and hopefully inspire people like you to do the same!"

Marc d'Entremont, Pombcoup Technologies

WATCH & LEARN

HOW WE'RE LEARNING AND SHARING KNOWLEDGE

Recirculating aquaculture systems technologies / Pentair

Rethinking fish farming / Rethink Water, Denmark

Some things to think about while you watch:

1. what natural resources do recirculating systems help to sustain?

2. What would happen if we didn't filter the water that fish are being raised in?

3. What are the by-products (*waste*) of a recirculating system? What can they be used for?

4. How are recirculating systems an example of doing more with less?

Oyster farming & oyster tumbling / Zapco Technologies

Innovative aquaculture tools / Fisheries & Oceans Canada

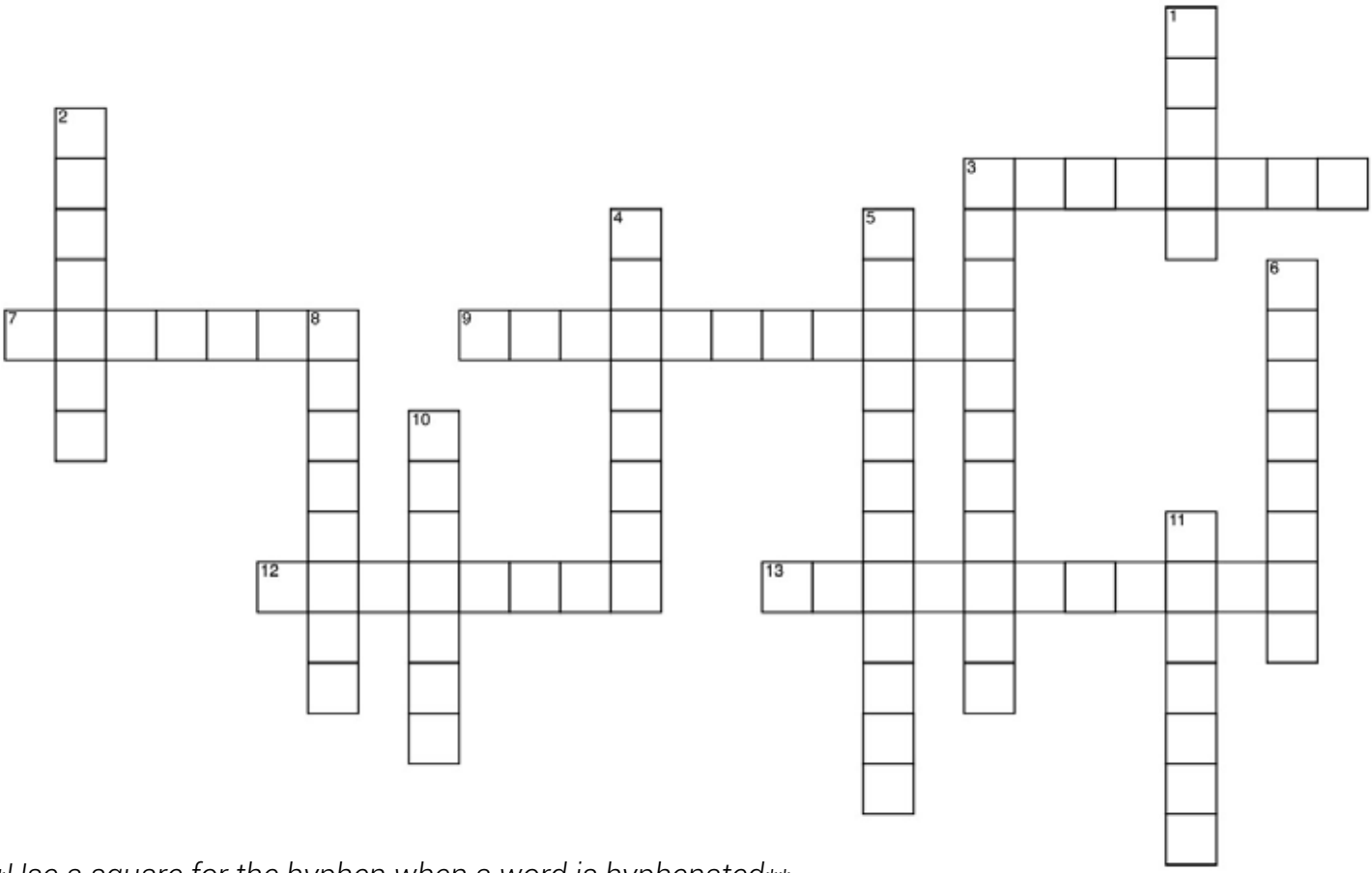
ACTIVITY: INDUSTRY ANALYSIS

No industry is without its flaws and its advantages. Use your own knowledge, and do some research online or have a discussion with friends or your family, to help you complete an industry analysis chart of traditional fishing and aquaculture (*a few have been done for you*).

FLAWS / ADVANTAGES	TRADITIONAL FISHING & HARVESTING	AQUACULTURE
Environmental Impact	• *drag nets damage natural ocean habitats and sea floors* • *fish that are accidentally caught in nets are thrown out (dead) as waste* • *fishing boats pollute air and water*	• *open-pen systems in the ocean can produce a lot of waste (fish poop and undigested fish food) that are smelly and gross and can raise bacteria levels in the water* • *fish can escape from open-pen systems and if they are sick, can bring that sickness to wild fish* • *closed-loop systems can have a positive impact on their environments because they are self-cleaning*
Providing food for people		• *Aquaculture already supplies 50% of all fish eaten, globally*
Managing fish stocks in the wild		
How it is affected by the warming of the ocean and pollution	• *Lobster are moving further north to find cooler water*	
How it is affected by storms and weather changes		
How it helps to provide food to the people who need it most		
How it gets food to people who don't live near the ocean		
How it deals with by-catch (fish and other creatures that are caught by accident)		• *There is no by-catch in aquaculture*

Based on your Industry Analysis, what advice would you give to industry to help the industry be more sustainable?

CROSSWORD PUZZLE



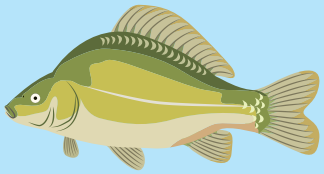
Use a square for the hyphen when a word is hyphenated

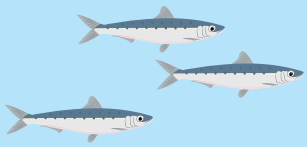
ACROSS

3 The fish and sea-life that are accidentally caught and thrown out
7 Technology that can be used in the water or in a net to sense if something has been caught
9 Type of farming that recycles the organic matter back into the system to keep it healthy and balanced
12 Technology that can be attached to a fish so we can track where it goes and how it spends its time
13 Farming the ocean and other water systems

DOWN

1 The one great, salty body of water that the whole earth shares
2 A type of sea plant that can be eaten or used in neutraceuticals
3 The 'waste' parts of fish that can be used to make other useful things
4 Where fish are kept in an aquaculture farm
5 Being able to find healthy and affordable food whenever we want it



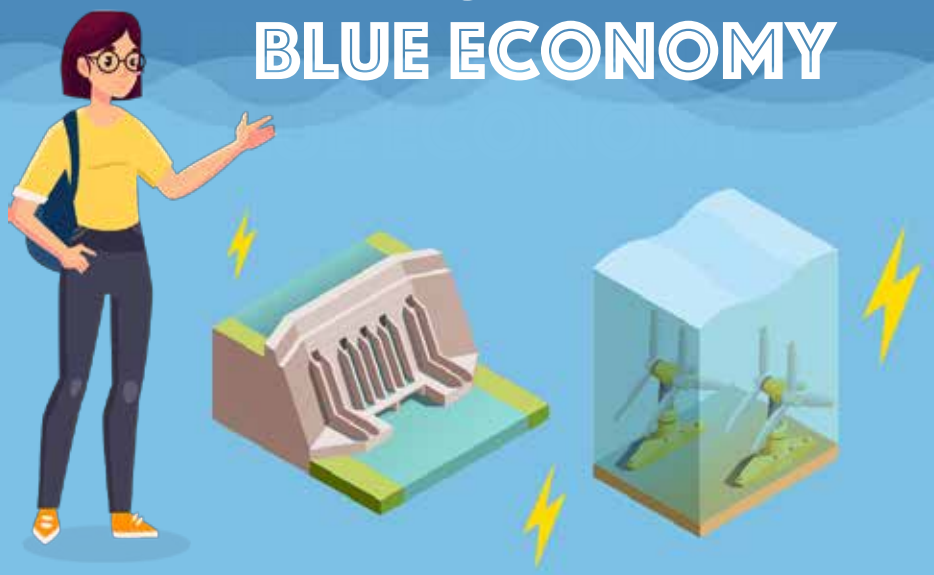


Across: by-catch, sensors, closed-loop, fishtags, aquaculture

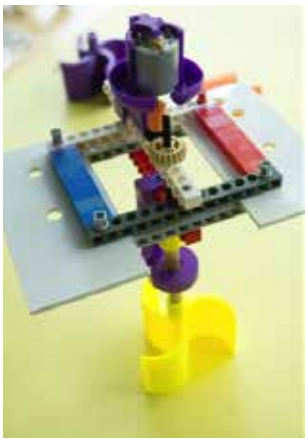
Down: ocean, seaweed, by-products, fishpens, food security

ENERGY AND THE BLUE ECONOMY

3



HOW I SEA THINGS...



- Taidg Molloy-Reilly, age 11, Halifax, NS

Tidal turbines generate electricity. No pollution comes out of a tidal turbine. I built a toy marine turbine knowing that I was learning about helping the world and it was fun actually doing it. You put tidal turbines in the ocean and I don't think they hurt animals that live in it.

ENERGY & THE BLUE ECONOMY

What happens when the lights go out? Have a look around your house or school. How many things around you run on electricity?

How much Energy do you use on a daily basis? How is that Energy made? Imagine what life would be like if that energy wasn't available.

ACTIVITY: ENERGY CONSUMPTION CALCULATOR

Click the link or scan the QR to this **energy calculator**.

You can do this activity alone, with a sibling, or with your whole family. You'll need to count the number of lights in your house, and you'll need to estimate how much time you use each appliance/ day (*for example, I have one toaster that I use in the morning, so I estimated the hours/day as 0.1*). See how much energy your house and family use each year.

What could you and your family do to use less electricity in your home? **Send us your bright ideas using Instagram** in a short video, tik tok, or poster to share with others. Remember to tag us @cove_workforce

ACTIVITY: STRETCH YOUR SKILLS

According to Stats Canada, there are 12.4 million households in Canada. Using your own home's annual energy use as an average, calculate how much energy is used by all Canadian households each year.

ACTIVITY:

Energy security means having access to affordable and reliable energy sources. This is more important than just being able to turn on the lights and charge our phones. Energy plays an important role in nearly every aspect of our lives. List what you think might happen if there is no power for the images below:


Cell Phone


Hospital


Grocery Store


Pharmacy


Restaurant


School


Streets


Bank


Factory

Energy security is important to us in our day-to-day lives, but also important to our economy, as having reliable energy allows us to do our jobs and meet the needs of people in our society.

QUIZ

Which of these factors relate to a country being energy secure?
(six are correct, one is not – click the ones you think are factors. Check your answer)

- a. Being able to rely on several different energy companies *(rather than just one)*
- b. Being able to generate energy from many different sources *(e.g. hydro, nuclear, solar, wind, natural gas, oil)*, rather than just one source
- c. Sharing Energy through trade with another country, like the US, to help out when demand is high, or supply is low
- d. Having the biggest stockpile of one source of energy (*e.g. oil*).
- e. Being a politically stable country without war or conflicts
- f. Having reliable and continuous access to energy (*where energy is available without interruption – the lights don't go out*)
- g. Being able to get energy to people across the whole country

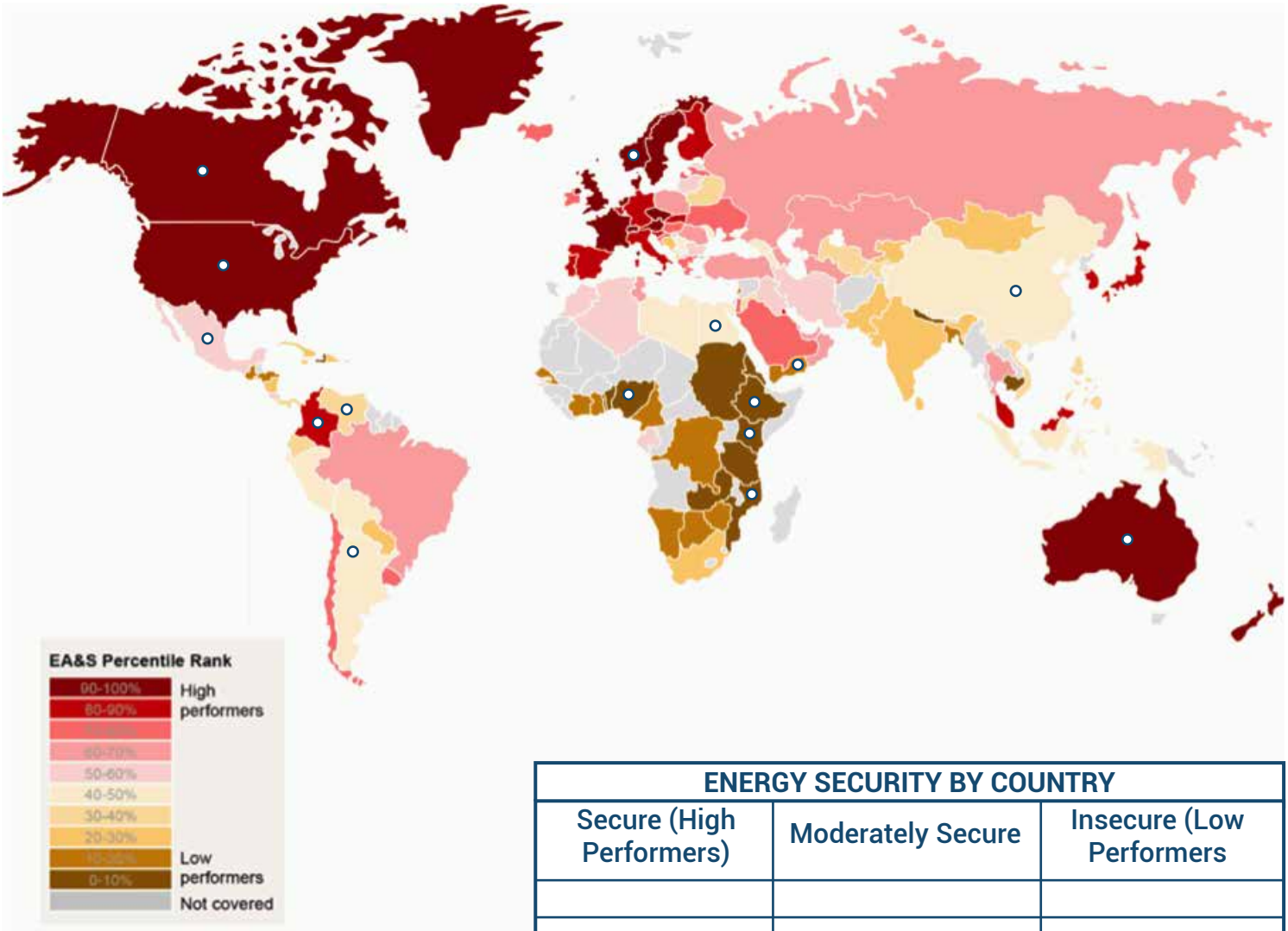
ENERGY SECURITY - WHAT IS IT?

This map from the World Economic Forum shows the energy security rating of each country based on their ability to meet the energy needs of their people.

- Energy Secure (*high performers*)
- Moderately Energy Secure (*mid-performers*)
- Energy Insecure (*low performers*)

Activity: Sort the following countries into the correct categories of energy security by filling-in the chart at the bottom. You can do this with a sibling, friend or parent to help you if you're not sure where the countries are located.

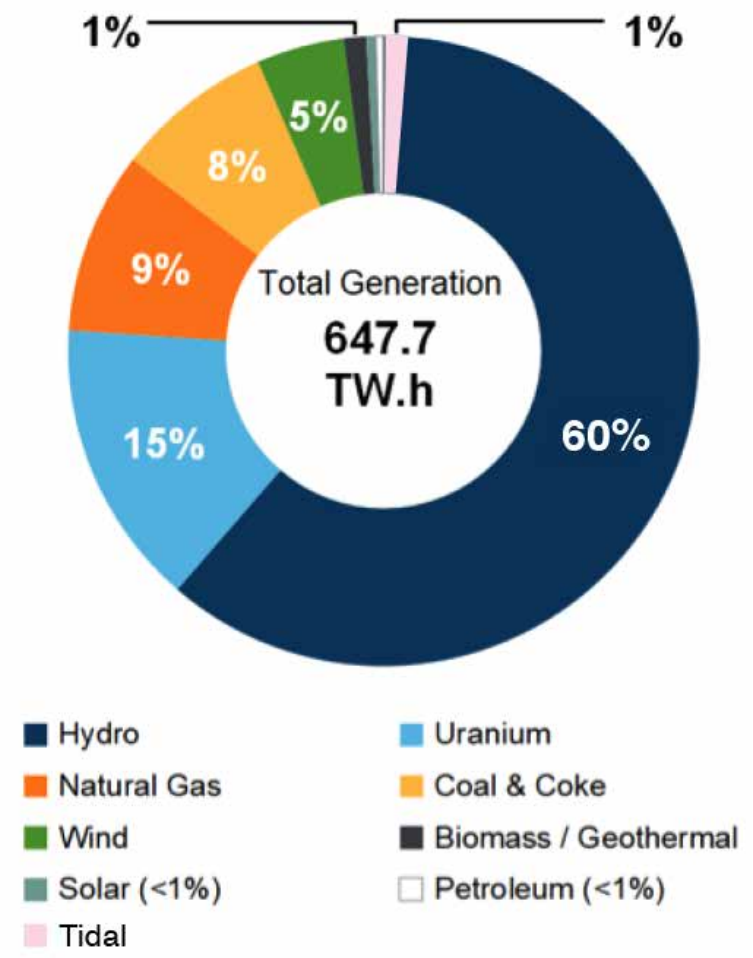
Argentina, Australia, Canada, China, Columbia, Egypt, Ethiopia, Kenya, Mexico, Mozambique, Nigeria, Norway, US, Venezuela, Yemen.



Source: World Economic Forum and Accenture analysis

ENERGY SECURITY BY COUNTRY		
Secure (High Performers)	Moderately Secure	Insecure (Low Performers

ENERGY SOURCES IN CANADA



- **Biomass is organic matter, like wood, food or animal waste, corn, or gas from a landfill, that can be burned as fuel to make electricity.**
- **Geothermal energy comes from the heat (thermal) energy that naturally occurs inside the earth.**
- **Renewable sources of energy aren't depleted – don't run out – as we use them. Like solar and wind – the sun keeps shining and the wind keeps blowing, even when we harness their energy.**
- **Non-renewable sources of energy are depleted – will eventually run out – as we use them. Like oil and natural gas – there is a limited supply on the planet, and once we use it, it's gone!**

Where does the energy we use in our homes come from?

Read the pie chart and complete the following statements:

1. Most of the electrical energy[1] that we use in our homes, schools and communities comes from _____. This means that we harness the energy from moving water and turn it into electrical energy.

2. Another _____% comes from 3 other forms of renewable energy, including _____, biomass/geothermal, and _____.

3. The remaining _____% is produced from non-renewable, extractive sources (meaning they are taken out of the earth and refined), including natural gas, nuclear (uranium), _____, and _____.

4. This pie chart represents all of Canada, but each province has a different mix of renewable and non-renewable energy sources. Use this link to find how energy is created in your province/territory.

1. *Canada Energy Regulator. www.cer-rec.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/cda-eng.html*

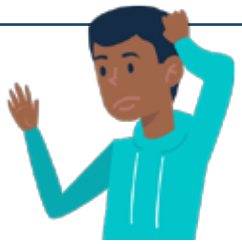
Is all Energy created equal?

Any type of energy that we use has pros and cons that relate to how we capture it (*i.e. solar panels, giant windmills, extracted from the earth*), how we store it (*i.e. giant batteries, oil tanks, power stations*), how we convert it to electrical energy (*i.e. by burning, silicon cells, generator*), and the waste or by-product that is produced (*i.e. smoke, steam, toxic gases, etc*).

See if you can list the pros and cons for the different types of energy sources listed below:

ENERGY TYPES	PROS	CONS
Solar 		• *very expensive*
Wind 		
Marine renewable 		
Hydro-electric 	• *generates a huge amount of energy from moving water*	
Oil, gas, coal, & natural gas 		

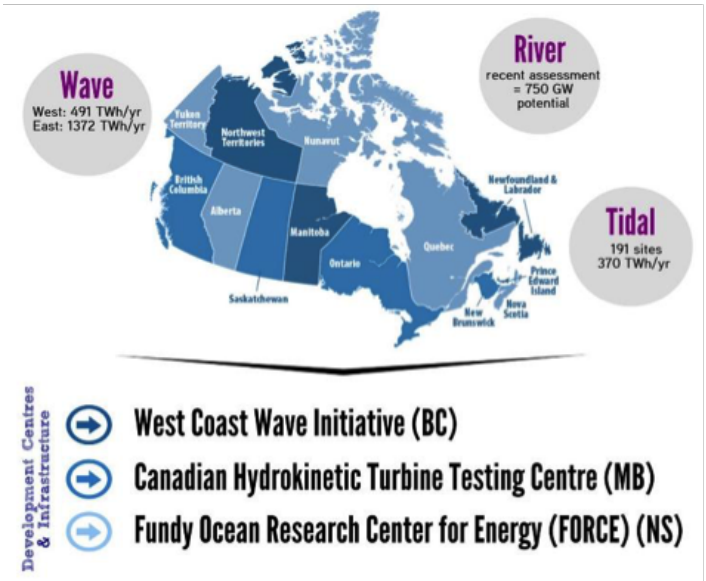
Based on your assessment above, what types of energy do you think are the energies of the future?



A DEEP DIVE INTO MARINE RENEWABLES

Across Canada we have several marine renewable energy projects underway to find new and better ways to harness the energy from moving water; both fresh water and ocean water. These include tidal energy projects in Bay of Fundy, wave energy projects in BC, and river turbines in Manitoba and Ontario.

All these projects have something in common – they are all developing new and improved technologies to capture the energy of moving water (*kinetic energy*) using turbines (*basically, an underwater windmill*) to convert it into electrical energy that can be used in our homes and schools



Making the most of our tides!

In Canada's Bay of Fundy, teams of marine engineers and technicians have been working on the huge challenge of finding ways to harness the incredible energy of the world's strongest tides. These tides are powerful and regular and predictable, making tidal energy a very attractive energy source of the future. But – it's tricky to harness these tides for a few reasons;

- We can't turn the tides off and on, so it's hard to get the tidal turbines into the water in the right place
- The tides are very strong, so it's difficult to keep the turbines in place. Lots of expensive equipment has been torn away by these tides already!
- Engineers need to think about the marine life that lives in the Bay of Fundy when they are designing their turbines – after all, we don't want to injure the marine creatures that call the Bay of Fundy home.
- Winter means ice – and ice can easily damage expensive equipment or carry it out to sea to be lost as ghost equipment.

These challenges make tidal energy a tricky option – but marine engineers and marine turbine technicians love a good challenge.

Representation of underwater tidal energy turbines

Nova Scotia's potential for tidal power is massive. It's more than four times the combined flow of every freshwater river in the world! That's an estimated potential of up to 60,000 megawatts (MW) of energy. And it's completely renewable - the tidal forces of the sun, moon, and earth are not depleted by harnessing the flow of water.

DESIGN THINKING CHALLENGE

What you need:

- Waterproof (*clean*) recyclables like lids from yoghurt containers, milk jugs, juice cartons, pop or water bottle, aluminum pie plates to make your propeller blades
- A long stick for the turbine to spin on (*like doweling, a pencil, a strong straw, a bamboo skewer*)
- Some glue (*glue gun is best*) or duct tape (*you'll need some pretty strong glue that is waterproof*), or you can try using putty or clay.
- A plastic bottle cap or cork or other material to connect the blades of your propeller to the stick
- Scissors or box cutters (*ask a parent or older sibling to help with this – safety first!*).

You should be able to make this turbine with materials that you find around the house -especially with clean recyclables.

Students at a COVE workshop creating their turbines from recycled objects

What to do:

- Before you start cutting and building, draw a potential turbine design – this will help you figure out what materials you need
- Consider the orientation (*which way it will spin in the water*), the shape and number of propeller blades,
- Also consider how you would deploy and anchor or moor (*keep the propeller in place*) the turbine in the water so it can spin freely
- Build your tidal turbine
- Test it under running water in the sink or bathtub – can you get it to spin freely?
- Have a look at some of the propellers other students and teachers have made

WHAT IN THE WORLD ARE THEY DOING?!

Offshore wind projects

Driving around Canada's provinces and territories, you've probably seen the giant windmills that harness energy from the wind to produce electricity. But did you know, that some countries have installed these giant windmills in the ocean to capture the powerful offshore winds?! These offshore wind farms can generally capture higher average winds than land-based ones, so they generate more power, and they don't take up any space on expensive land. **Denmark was the first country to dive into offshore wind farms.**

We don't have any big offshore wind projects in Canada yet, for a few reasons.

- First of all, in Canada, land isn't a problem. We have a lot more open space on land for wind turbines.
- Also, mooring the offshore turbines, and using underwater cabling to get the energy back to land for people to use, make offshore wind energy more expensive per kW than land-based wind-turbines.
- In Canada NIMBY (not in my back yard) is a big consideration. This means that some people like the idea of offshore wind turbines, but don't want them off their shores.

Why do you think that is? Why might people object to having a wind farm in the ocean within view of their homes?

Offshore wind rendering / credit: Enrique Lopez Garre

Moorings are the ways that the wind turbines are anchored or held in place – we don't want our expensive wind turbines to drift away! Sometimes a floating platform mooring is used, other times, when the water is shallower, a solid foundation is driven into the seabed, or a tripod bottom is used (*three legs*) or a gravity foundation is used (*a concrete base that rests on a seabed*).

Which mooring do you think would be best in Canadian waters? Which would have the least impact on the marine environment (*the living things*)?

Activity: Can you modify your marine turbine to become an offshore wind turbine? What changes will you make to harness wind energy versus tidal energy? Think about how you will moor it to keep it in place. Try it out in your sink or bathtub. ****CAUTION: if you are using a fan or hairdryer to create your wind, keep it well away from the water. Ask an adult to help.**** Share a photo of your design with us on Instagram - tag us @cove_workforce and use #COVEWI

MEANWHILE IN CANADA

Dr. Sue Molloy onboard a research vessel with Glas Ocean.

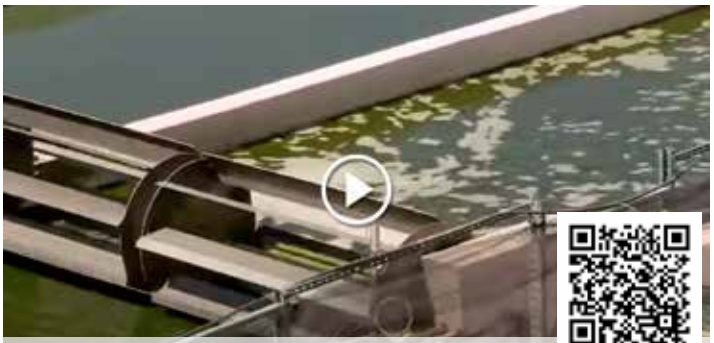
Dr. Sue Molloy is a ocean engineer and an entrepreneur in Nova Scotia, Canada. She designs innovative and sustainable ocean technologies to help us use the ocean's resources more carefully and more efficiently. Dr. Sue loves the ocean, and wants to keep it clean and protected.

Electric Boats

Glas Ocean is a company that was started many years ago to do work on ocean engineering projects. "Glas" isn't glass misspelled; it's the Irish or Gaelic word for green, so in English the company name is Green Ocean. This name was chosen because they focus on sustainable and environmentally responsible ocean projects. Some of their projects include developing tidal power projects, doing research to see if we can understand how tidal power impacts fish, underwater noise projects to see ways to reduce underwater noise on whales and other marine animals. They have also developed a boat to use an electric motor with a battery. They're hoping to be able to charge the battery with solar energy so it is completely 'glas'.

Wave of the Future! Biofuels

Did you know that the fuel of the future might be growing in your fish-tank right now? Yep – algae grows by absorbing sunlight and CO_2 (*a gas that leads to global warming*), and stores the energy as oil that can be burned to generate electricity. So, it absorbs greenhouse gas, releases oxygen that we breathe, and produces fuel in the process. How green is that!?!



Using algae for power in the growing biofuel industry / energy.gov

SabrTech, Nova Scotia

SabrTech Inc. is a Nova Scotia-based cleantech company that designs, develops and invests in sustainable technologies. Imagine a world where farmers could produce their own fertilizer on site, developing countries could clean their water, the oil industry could trap their CO_2 emissions, and we could feed farmed fish without depleting our wild fish stocks. This is what SabrTech dreams about.

The RiverBox is a system for growing algae that can be used for food, fuel, nutraceutical (*health supplements*), chemical or personal care uses. Forward-thinking entrepreneurs like Mather Carscallen work to sustainably solve some of today's most complex global problems and preserve the ecosystem that we call home.

Algae being grown for food, fuel, and more.

HOW I SEA THINGS...

Photo: Nova Scotia Sea School, 7-day Coastal Sailing Expedition

- Lyra Arruda Kyriakidis, age 16

Being on a sailboat is like being in your own little world. The ocean is a vast and wonderful place and you are just a tiny speck bobbing on the surface. The stars seem brighter, the breeze seems saltier, and you feel completely free. On the ocean you can go anywhere, see everything, do anything.

Scramble the Blue Economy:

See how many words you can make from the letters in the words B-L-U-E E-C-O-N-O-M-Y.

How many 2-letter words can you make?

How many 3-letter words can you make?

How many 4-letter words can you make?

How many 5-letter words can you make?

Can you make any longer words? Share your list with us through a direct message on Instagram: @cove_workforce.

Word Find:

WKISFROENERGYMLKPB
JINKLOSDUWAQZNOPOI
BNACHXGEOTHERMALO
TKIJSEFRENEWABLEPLM
UXPOROLSOLARGHDJSA
RNWINDMHUYSWAHGS
BMARINELINITFRENWJS
IRENENELECTRICITYOP
NMOORINGSLIURFIDQU
EOCHILSFHLIEBIOFUELI
WEBLUEECONOMYNORT

The following words are hidden above, horizontally and vertically:

geothermal
energy
blue economy
biofuel
solar
wind
marine
biomass
mooring
electricity
renewable

THE BIG BLUE HIGHWAY

4

HOW I SEA THINGS...

- Leah Pengelly, Alberta

For me the ocean is my playground, my classroom, my teacher, and my job. It has always captivated me with its complexity and interconnections. Studying the ocean continually leaves me with new insights and more questions. Being able to study the Arctic Ocean has emphasized the importance of our connections to the ocean and how even remote waters are impacted by our actions. This pushes me to ensure that those who come after me can still be inspired by a polar bear hunting on the sea ice, or healthy tropical reef, or a pristine wave crashing over the beach.

Photos: SOI.com

THE BIG BLUE HIGHWAY

The ocean is a waterway, for travel, shipping, recreation and tourism, fishing, research, and defense and surveillance. At any given moment, there can be thousands of boats and ships on Canada's waterways, and millions sharing the water across the globe. Remember that we said in section 1 that most of the things you buy, use, wear, and even eat, have spent some time traveling to you by water? Why do you think boats and ships are an efficient way of transporting these things around the world?

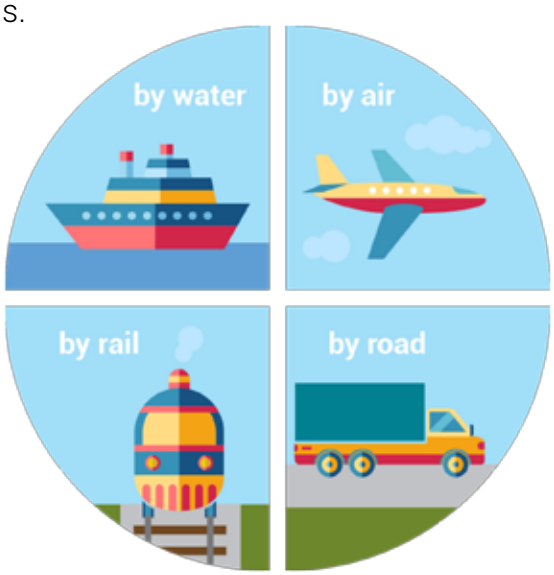
Let's compare the pros and cons of four methods of transporting goods to stores and people:

By water – low carbon footprint, cheaper, can ship things anywhere around the world that is connected by a waterway, can transport huge shipments of good, but this is a slower option

By air – highest carbon footprint, fastest option, but also most expensive option, can transport smaller shipments of goods, a great option for luxury goods, but not for everyday things

By road – can get goods to even remote places that are connected by roads, the roads stop at the water so no way to transport things internationally, high carbon footprint, can transport smaller shipments of goods,

By rail – low carbon footprint, limited to areas that have rail service (*like big cities*), but not accessible in remote areas, can transport larger shipments of goods.



BOATMAKING THEN...

Contributed by Tim Edwards, MRINA

Over 100,000 years ago

The first type of boat used by humans was really a raft. The raft might have been a floating tree, a bundle of reeds, or even a dead animal. It wasn't designed to be a raft - humans simply discovered you can float across the water by hanging on to, or climbing onto an already-floating object without having to swim or exert much effort. They would also have used rafts to survive floods. The first "voyages" were probably across rivers, and small lakes to expand areas to hunt for food, and the direction the raft went depended on the direction of the wind and water current at the time.

From 100,000 to 50,000 years ago

Discoveries at archaeological sites in southern Europe show that rafts were used to cross larger bodies of water, like the Mediterranean. Humans were starting to inhabit new areas of land, and rafts were a convenient method of travelling. As recently as the last century, rafts made of inflated animal skins were still being used in some parts of Asia.

Traditional raft of inflated animal skins used in Asia.
Image: www.aramcoexpats.com/articles/kelleks-the-inflatable-rafts-of-yesteryear/

Humans using tree trunks as floating rafts observed that hollow trees floated better than solid ones. The hollowing-out would have been caused by insects eating the inside the tree as humans hadn't yet invented tools to cut, hollow out or shape wood.

From 50,000 to 10,000 years ago

Rafts made of bundles of hollow reeds were used in parts of the world where this type of plant grew, such as in ancient Egypt.

North African boat made of reeds by modern researchers
phys.org /news/2019-07-ancient-egypt-to-black-sea-route-adventurers.html

One region where reed rafts are still used to this day is Lake Titicaca in South America.

Village in Lake Titicaca, Peru

From 10,000 to 2,000 years ago

It was during this time that rafts became boats. This means they started to have a shape that made them easier to travel through the water.

As humans started using more sophisticated tools for hunting, they also used items such as animal bones for cutting skins and wood. This meant logs could be hollowed out by hand to form what we call the "dugout" canoe. At the same time, especially in the far North, humans started to make boats out of animal skins stretched over frames of animal bones. This boat construction method was simply copying what man had observed in animals. After all, their skin (*as is ours*) is stretched over our skeleton to form a watertight seal.

Stretched-skin boat. Photo: Matthew M. Schoenfelder / Getty Images

A refinement of the dugout canoe is the birch bark canoe of the First Nations peoples of Canada.

Birch bark canoe. https://www.historymuseum.ca/blog/birchbark-canoe-is-invented/

During this time, methods of propelling these boats through the water developed. Paddles or poles were used, rather than just using hands. And the idea of capturing the wind in a sail to blow the boat along developed too. Early sails were likely made from broad palm leaves and were first known to be used in the Middle-East.

A further development of the paddle was the oar. An oar is basically a mechanical lever that increases the power of a man's arm and transfers it into the water to move the boat forward. The ancient Egyptians of this era perfected this new propulsion method. Oars also started to be used as early rudders.

Depiction on a tomb wall of Egyptian oared boat. Photo: www.quora.com

From 2,000 to 1,000 years ago

This period saw big developments in boat design and construction. The discovery and use of metal tools meant trees could now be cut and shaped into planks to form the hull of a boat. The Vikings in Northern Europe perfected the technique of building long, sleek and seaworthy boats, using what's now called the "lapstrake" building method.

Rendering of a Viking ship

Historic Viking village preserved in Torgelow, Germany.

The Romans also built strong and capable warships of wood, some with several decks of rowers sitting one above the other to give awesome propulsion power.

Roman wooden warship. Image: https://www.ancient.eu/trireme/

AND NOW...

In recent time

The coming of the Industrial Revolution in Europe, almost 400 years ago, triggered another huge change in the way boats and ships were built. Wood was gradually replaced as the main shipbuilding material by iron and then steel. The invention of the steam engine and propeller meant sailing ships became less efficient to transport cargoes around the world – and they only remained in use for certain things, such as in certain fisheries – like Canada's Bluenose schooner.

The famous Canadian Bluenose Schooner
Image source: https://www.thecanadianencyclopedia.ca/en/article/bluenose

Photo: World Sailing Show, May 9, 2017

The use of boats for recreation is really a very recent event. As an increasing number of people had more time to relax on the water, the demand for yachts and motor boats increased. Building materials for pleasure boats changed too – wood largely being replaced in the mid-1900s by fibreglass.

Today, most boats are built of what's called "composites". This includes fibreglass, or carbon fibre and Kevlar for boats that need to be stronger, but light in weight.

What main lessons have we learnt about boat design after all these years?

The main thing to understand is that over the past hundred thousand years, boat types and shapes have evolved to match the local waters, the available building materials, and their intended use. This is still the case today.

ACTIVITY: WORD UNSCRAMBLE

Here are a few different types of water vessels. See if you can unscramble the letters to figure out the different vessels in this list. Can you match them to their image?

YRDO _ _ _ _

GHNIFSI TABO _ _ _ _ _ _ _ _ _ _ _ _

ESRICU PHIS _ _ _ _ _ _ _ _ _ _ _ _

ELATBT SPIH _ _ _ _ _ _ _ _ _ _ _ _

CIE KREABRE _ _ _ _ _ _ _ _ _ _ _

URDGATCAOS ISPH _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

TISALOAB _ _ _ _ _ _ _ _

ANACTRAMA _ _ _ _ _ _ _ _ _

EINMRABUS _ _ _ _ _ _ _ _ _

OCERINTA IHPS _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

YRFRE _ _ _ _ _

CRHIB ABRK EONAC _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

NIGYD _ _ _ _ _

YKAAK _ _ _ _ _

Canoe made from hollowed-out log in the Amazon

Gondola transportation in Venice

Floating market in Bangkok, Thailand

BOATS AND SHIPS HAVE LOTS IN COMMON

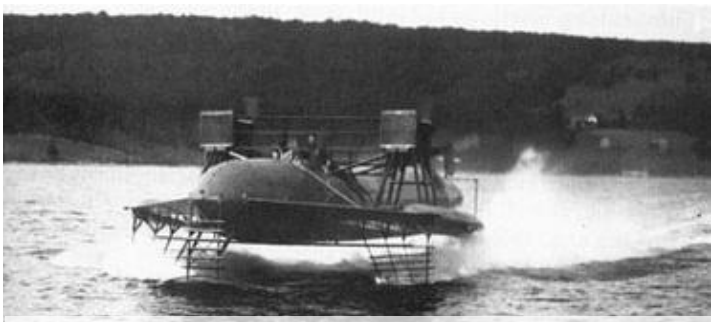
These two water vessels may not look much alike, but they have a lot in common.

Motorboat

Cruise ship docked in a harbour

We've listed some common parts of a vessel below. See if you can identify them on each of these boat images above.

- **Hull:** the body of the boat
- **Beam:** The width of the boat, at its widest point. Usually, a wider beam means a more stable boat.
- **Bilge:** A compartment at the lowest point of a boat's hull that often has water in it.
- **Waterline:** Where the boat sits in the water.
- **Keel:** The backbone of a boat. It is the lowest point of the boat's hull. Like our own backbones, the keel provides strength, stability and prevents sideways drift of the boat in the water.
- **Main deck:** the flat part of the boat or ship above the hull
- **Superstructure:** the part of the boat or ship built above the hull and the main deck. This is where the view is best.
- **Propulsion system:** this is the propeller or other system that propels, or makes the motorized boat move.



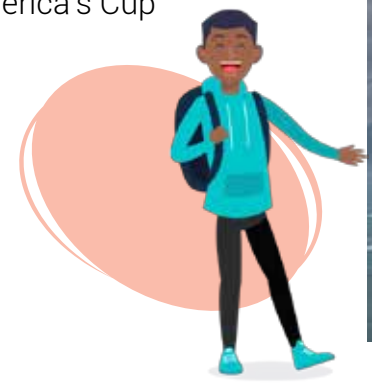
Original Hydrofoil design by Arthur Graham Bell
image: thecanadianencyclopedia.ca/en/article/hydrofoil

Watch this video which explains how a hydrofoil works.

WHEN BOATS TAKE FLIGHT! : THE HYDROFOIL

Did you know that the first successful Canadian-built hydrofoil was built in Baddeck, NS – by Alexander Graham Bell? Along with his wife Mabel Bell and the engineer F.W. Casey Baldwin, they designed a watercraft with hydrofoils, or small rails, that lift, just like an airplane's wings, when the craft gains speed. This 'lift' literally lifts the hull of the boat off the surface of the water, which reduces friction and allows the craft to travel at greater speeds.

Here's another great YouTube video showing hydrofoils racing in the America's Cup



CAREER PROFILE: ELECTRICAL ENGINEER & SHIP DESIGNER

In ship design, there are some people who specialize in ships from the beginning of their training, but there are also many other jobs that are done by people whose training wasn't dedicated to the shipbuilding world.

That describes me – I'm an electrical engineer. I design the electrical equipment and systems that go on ships. This can be the main propulsion motors of modern electric-drive ships, but it can also be the ship's computer system, its radars, its phones, its fire alarm system, its navigation lights, or the electric heaters that help keep the railings from getting covered in ice during a winter storm. Electricity is everywhere on a modern ship, and it's my job to figure out how to get it there, so it can do its job.

I'm originally from the Pacific coast – a small town called Bella Coola. After high school, I studied Electrical Engineering at the University of Toronto. My first technical job after university was designing and testing electrical switchboards with a small company in Newfoundland. Soon after learning the ropes there, I was recruited to co-ordinate electrical engineering at one of the world's major international shipyards – Ulstein Verft, in the small town of Ulsteinvik, Norway. That was a fascinating job, watching an enormous ship take shape outside my office window – and knowing that the work I was co-ordinating was making it all possible!

Ashley Morton, Electrical Engineer and now, High School Teacher

I returned to Canada in 2011, and have worked on ferries, Naval ships for the Arctic, clam fishing boats, pilot boats, solar-powered tour boats, and an enormous tidal-energy turbine project. I live in Halifax.

Over my career, my work has taken me to nine countries, the shores of three oceans, and I get to watch with pride as ships I've worked on sail past the window of my house in Halifax all the time. It was incredibly rewarding work. I say "was", because after 15 years of doing that work, and loving it, I've decided to go back to school to learn how to become a teacher, to teach future ship designers – when they're in high school.

SHIP-SHAPE!

Contributed by Ashley Morton, Ship Designer

"Shipshape" used to be a common term to describe things being organized and tidy, with everything in its place – like your room, right? But what shape is a ship? And why?

Part of a ship's shape is set up by the simple fact that it has to float – it's kind of a big wood, fibreglass or metal bubble, floating on the water – but it needs to stay with the up-side up, and the down-side down.

But people figured out how to do that part thousands of years ago, all over the world. So why do today's ships and boats have so many different shapes?

Think about the kind of questions you might ask if you were asked to design a ship:

- What work does the ship need to do?
- How many people need to go on this ship?
- How long will the ship be away from land?
- What kind of weather will the ship need to be able to travel in?
- Will there be ice on the water that the ship is travelling on?
- How will the ship be powered? *(Sail? Oars? Diesel fuel? Solar-generated electricity?)*

So does this one, even though it's much smaller:

All those questions are important, but the starting point is often the first one – what does the ship need to do?

Look at this ship. Why do you think that it has a low, flat section towards the back *(the "stern", in ship-speak)*?

The first one is a type of vessel called an "Offshore Supply Vessel" – It travels back and forth from land to offshore platforms, bringing cargo and equipment. The second one is a lobster fishing boat. It travels back and forth from land to fishing grounds, carrying lobster traps on its stern.

Both of them have to be able to have a lot of weight loaded on to them, and they want to keep that weight pretty low down, to make sure that the ship doesn't become unstable and tip over. They end up looking a little bit like "pickup trucks on the water".

In what other ways are these two vessels similar and different?

But there are hundreds of other different types of ships and boats in the world, and they all have shapes that are determined by what they're trying to do.

Can you think of how your ship would need to be shaped if you needed …

1) to have cars drive on and off it?
2) to tow something heavy behind it?
3) to be able to go backwards as fast as you went forwards?
4) to be able to break through ice?
5) to be able to carry absolutely as much cargo in containers as possible?
6) to be able to carry cargo that was liquid like oil or chemicals?
7) to travel through very shallow water?
8) to travel under very low bridges?

ACTIVITY:

Number each one of the ships or boats here with one of the jobs listed above. (*Answers here*)

Photo: Chiz99 / Wikipedia Editor

Photo: US Navy

Photo: Tedz / Wikipedia

Photo: Kees Torn / flickr

Photo: Verne Equinox

Photo: Walter Siegmund

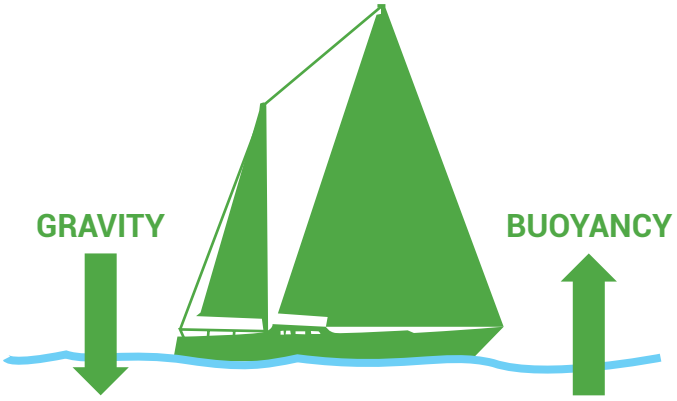
Photo: Phil Nash from Wikimedia Commons

Photo: David Wilson

WHY DO SHIPS MADE OF TONNES OF STEEL STILL FLOAT?

Gravity versus buoyancy - gravity is constantly acting upon us, pulling us down to earth. But in water, another force is at play that keeps us from sinking straight to the bottom of the water. It's called buoyant force, and it's an upward force. When objects float in the water, the forces of gravity and buoyancy are in equilibrium – which means they are in balance. Ship design must always keep these two forces in balance.

- Gravitational force on an object (*the pull of the Earth*) is a downward force that pulls us to the Earth.
- Buoyant force is an upward force that acts on objects in the water.



Other considerations for keeping boats and ships afloat

1. Stability - Ships and boats in the water are constantly in motion, even when they're anchored or tethered to a dock. That's because water is always in motion, with currents and tides, wind and storms keeping it moving. So we need to think about stability. Stability means simply, keeping the up-side up, and the down-side down.

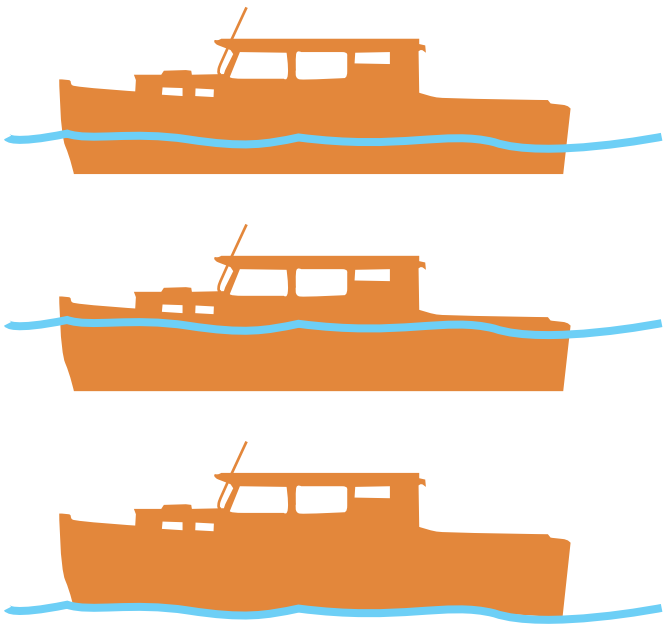
2. Seaworthiness - This means that a vessel is safe to travel on the water. This means that it will right itself if a wave tips it over, and that it won't take on too much water to stay afloat. When you design your vessel, you will also have to ensure that the material you use is waterproof, because soggy is definitely not seaworthy.

3. Load - all boats and ships carry something – be it people, or cargo, or vehicles. Think about how load affects stability? Do you want the heaviest load up top in the superstructure, on the main deck, or down in the hull?

4. Plimsoll Line - The Plimsoll Line, is a line on the outside of a ship or boat or that shows how low in the water it can safely travel. By adding more 'load', the vessel sinks lower into the water. The Plimsoll Line will change depending on the water conditions (*temperature, fresh water and sea water*). Most boats use a different coloured paint to indicate the Plimsoll Line.

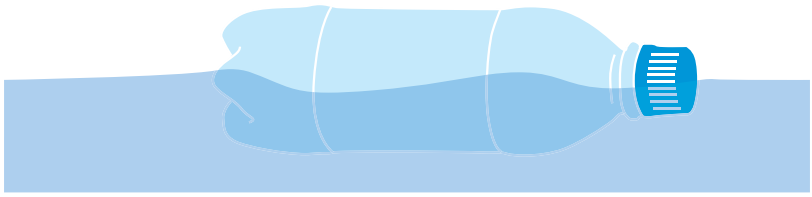
Plimsoll line showing the water levels for safe travel with loads

Have a look at these images and decide which one looks most stable and buoyant? Where would you put the load?



Activity 1: Take a clean plastic or glass bottle (be careful with the glass) with a lid. Fill it half-way with water, close the lid, and see if it floats. Imagine that the top half of the bottle is the main deck, so we want to keep that out of the water. The water inside the bottle is the 'load'. How much load can you put inside and still keep the bottle afloat? Using a marker, draw the Plimsoll Line on the bottle to show where it floats best in the water.

Activity 2: Take the water bottle that you drew your Plimsoll line onto. Is it stable in the water or does it roll freely? Can you imagine what would happen if you were on a boat that rolled freely? What can you do to the water bottle to make it float with more stability? Share your design with us on Instagram **here, Tag us @cove_workforce**



DESIGN THINKING CHALLENGE

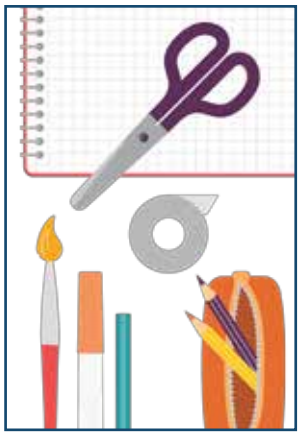
How purpose informs design

So now we know that purposeful design means that the vessel design is determined by the purpose or use of the vessel. But what else needs to be considered when choosing a vessel design?

Well, it's important to know the **type of water** it will be in (*salt water, fresh water*), **how much load** it will carry, what type of load it will carry (*liquids, solid goods, people*), the **type of water conditions** it will travel in (*deep ocean waves, narrow rivers, ice*), **the duration of trips** (*quick back-and-forth like a ferry, or weeks at sea like a Navy vessel*), and what **type of equipment** (*like research equipment, helicopters, combat systems, or fishing gear*) or systems it will need.

Using the information above, and clean materials from your recycling bin, design and build a simple vessel. Keep the vessel purpose in mind as you plan your design. Use materials available, including clean materials from your home recycling, along with duct tape and a glue gun. Design and build a hull and superstructure (*i.e. Captain's Bridge or living quarters*) that will float, that can support a load, and that remains stable, buoyant, and seaworthy in turbulent water.

Stretch your skills: For a more challenging build activity, **click here** for instructions on how to build a model of an Arctic Offshore Patrol Ship (AOPS) (**click here for the COVE shipbuilding activity**)



Most seaworthy model and the happy students who built it

AOPS models created by students at a COVE workshop.

It is a ship currently being built in Halifax, Nova Scotia by Irving Shipbuilding Inc. Like the AOPS, this is a team build, so work with a parent or sibling. This activity was designed by an engineering team from Irving.

Test your vessel in the sink or bathtub.

- Does it float? • Is it stable?
- What happens if you add load to it?

Extension Activity: Take a baggie and fill it with sand or stones or marbles. This is your 'load'. Position the load on your ship where you think it will be most stable and least stable.

PORTS AND HARBOURS

Captain Allan Gray, CEO, Halifax Port Authority

Over 90% of the worlds trade is carried on the sea. Ships of various types carry goods in ships holds or containers to all parts of the world. But how do those goods reach your home or to the industries that need to turn them into useful items that you use? Ships must come to ports and ports must be safe, secure and efficient. Ports employ many people directly doing jobs like Port administration, pilots, tug drivers and stevedores but also just as many if not more indirectly have jobs around ports like truck drivers, container packers and unpackers, surveyors, and engineers. Because of this, our ports are very important to the economy of the country and very important in generating jobs for the future. Ports were originally established as part of the first settlements of many countries and therefore are often found close to cities. Originally this was important as it would take too long to move goods inland.

Today goods are loaded or unloaded from ships and may travel many miles by truck or rail from its origin or to its destination. The ports however continue to grow as the city around them grows. It is important that ports and port cities learn how to grow together in a sustainable way.

The port gives a port city its identity, culture and heritage but as it grows it needs to ensure that it can do so without impacting unfairly on the lives of those who live near it. Smarter ways of doing things and new technologies allow ports and cities to coexist while growing together.

Shipping containers ready to be loaded for transport through the port.

The MacDonald Bridge spanning Halifax Harbour

Some of the different water craft that use the Port of Halifax and the Harbour

Check out this video to see how container ships work.

DESIGN THINKING CHALLENGE

Design and build a crane to lift containers onto and off of vessel.

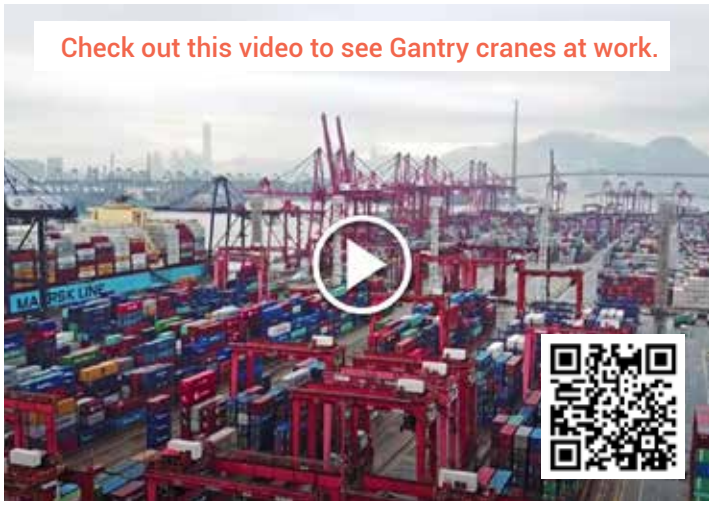
You will need:

- Some different weights (*you can use baggies and fill them with different amounts of 'cargo' like sand, marbles, or dried beans*)
- Something round for a pulley system (*like a spool of thread or a clean can or bottle*)
- Thread or yarn
- Some kind of hook (*you can make your own from a paper clip*)
- Some sturdy material for your crane, like wood, strong cardboard, a tall plastic bottle
- A sturdy base to mount your crane on, like a piece of wood

What to do:

Design a crane that uses a pulley system and levers to lift a heavy weight from one place and move it safely to another place (*or use it to load 'cargo' onto the ship you have built – without tipping or sinking the ship*). You might want to check out some simple pulleys and levers online to get some ideas. Share a photo/video of your design **with us on Instagram: @cove_workforce**.

Check out this video to see Gantry cranes at work.



Mistakes we've made and how we're using information and technology to do better

One way to help keep oceans clean and its resources sustainable is to not contaminate the water where our seafood comes from. The lowest, or bottom section of a boat is called the bilge, and is designed to collect excess water. On vessels of virtually any size, a pump inside the bilge performs a very important function: it removes water so the boat doesn't sink. Boat engines and fuel tanks are often located in the bilge and when they leak oil, fuel and grease (*known as hydrocarbons*), they get mixed in with the water and are also pumped overboard. GreenOil provides a very unique bilge water filter system that removes hydrocarbons from the bilge water before it is pumped overboard. As more and more boats install these systems, we can help keep our oceans clean to provide the highest quality seafood possible.

Industry at work solving the problem of bilge water

Greenoil: With an estimated 4.3 million boats in Canada, if each boat pumped just 1/2 litre of hydrocarbons per season, that would equal more than 2 million litres of contamination per year. The legal contamination level in Canada is 15ppm, meaning 15 litres of hydrocarbons will contaminate 1 million litres of water. So, over 2 million litres of hydrocarbons could contaminate over 133 billion litres of water!

Here are some other people who are already working in the Blue Economy.

Red Seal Journeyman Joiner / Boat Builder / Carpenter / Furniture Maker

I fell in love with boats when I was in high school. I grew up working with a sail training organization in Toronto called 'Toronto Brigantine'. I always knew I loved being around the water and wanted to learn more about building and repairing boats so after I finished university I went to college and took a fine woodworking program. It taught me a lot about using tools correctly and methods of construction. I love building and designing furniture, but I always knew my goal was to work with wooden boats. I felt and still feel if you can build boats you can build anything. After college I applied to all the wooden boat shops around until one agreed to take me. I learned most of what I know from working on the job. Boatbuilding and woodworking in general, as I have worked building furniture, fine interiors and carpentry, is all about solving problems. Wood is a very unique medium as it is always moving and changing. There is constantly some new challenge to overcome or construction detail to consider, it keeps you on your toes and always learning. I love it and use the skills I have gained in my career, including confidence with tools, problems solving skills and thinking outside of the box, every day of my life. I couldn't imagine it any other way."

Erin Philp working on a project

- Erin Philp

Andrew Rhodenizer in his workshop

Journeyman Wooden Boat Builder

"Wooden Boat Building was something which was passed down to me in my family and has come to represent for me continuance; meaning it is a craft and a practice that can survive throughout time for many reasons. Wooden boatbuilding is a trade which encourages a community to work together and requires a whole team of people to live and work in a way which supports everyone involved; starting with the arborist, then the sawyers, then the iron workers, a boat builder or shipwright & many others.

It is a trade that can only continue, and has continued through generations because it can be sustainable; meaning we work with the environment, and take only what we absolutely need, and leave plenty for others. This makes sure that wooden boats are an industry which will always be here waiting for you!" Boat Builder

– Andrew Rhodenizer

Sailmaker's Assistant, NSCAD graduate

"Coming from Alberta, I never thought too much about the ocean until I moved to Halifax to go to Art School. I was instantly hooked! I soaked up information about boats and worked on them whenever I could, just doing small jobs. Sail boats did, and still do feel like a little bit of magic to me. What I do now, Industrial Sewing, is just sewing on a larger scale! For boats! I use a big strong sewing machine to get through thick fabrics, and I get to do lots of fun rope work and hand sewing! Before I was hired as a Sail Maker's Assistant, I did not have any formal training, but had a bit of sewing experience and was willing to try it out! I learned much of what I know about the trade while doing that work, and it allowed me to strike out on my own & work for myself at home! I like this trade because I get to work with my hands, see & learn about lots of different boats & know their stories, and make them sewn items to protect them from the weather! It requires me to think visually (which I love), and solve problems with materials and shapes which my Art School training really helped me with. I never thought I'd end up doing what I do, but I'm very glad I found it by trying, asking lots of questions, and constantly learning more."

Erin Robison at work making sails

– Erin Robison, Marine Industrial Sewist and Ocean-Based Artist

THE NAVY IN THE BLUE ECONOMY

Contributed by – Vice Admiral James (Jim) King (retired)

I grew up near Montreal, far from salt-water, 1000 miles from the sea. I first read about the sea as a schoolboy and would see navy and coast guard ships on the St Lawrence Seaway. It would lead me to join the Navy through a scholarship which paid for my university education. During the summer I trained at sea on both coasts. I spent a career in the Navy - fifteen years at sea - years interspersed with periods ashore training and working in Halifax, Ottawa, London and Brussels from where I retired as a Vice Admiral.

The Navy is full of fun and adventure. It exists to protect our country and our way of life and the lives of many people around the world. It's about traveling the oceans of the world with young Canadian men and women in modern, high-speed ships, submarines and aircraft. The Navy shares the ocean highway with fishing vessels, merchant ships, research vessels and oil and gas rigs. It's about using computers, radars, sonars and other high-tech equipment. It's about learning to fire guns, missiles and torpedoes and to use rifles and pistols safely and effectively in the protection of yourself, your ship and your shipmates. It's about getting closer to the environment and sea-life in the oceans and carrying out research and observation to preserve them. It's sharing in exciting work, friendship, laughter, fitness and lots of good food. Finally, it's all about making a difference in this beautiful world of ours. It's not for everyone but it might be for you.

Vice Admiral James King (retired)

CAREER PROFILES: SHIPBUILDING

Kevin McCoy
Vice Admiral, U.S. Navy (retired)
President, Irving Shipbuilding

I grew up about ten kilometers from the ocean. As a young boy, I would go to the beach and dream of sailing on a big ship around the world to new and interesting places. When I was thirteen, I bought a small sailboat and taught myself how to sail. I learned everything I could about the tides, waves, and wind and their effect on a boat. It fascinated me.

When I graduated from College, my love for the sea carried me into the Navy where I served on both submarines and surface ships for 36 years. I traveled all over the world in the Navy, from the bottom of the ocean to the top of the world in Tibet. I studied Naval Architecture and eventually became the head of the U.S. Navy's ship design and construction activities.

After I left the Navy, I learned about the Royal Canadian Navy's effort to restart shipbuilding in Halifax, Nova Scotia. I wanted to be part of bringing back shipbuilding to a terrific Maritime community. I have been building ships in Halifax now for seven years and I still get the same sense of wonder being around the ocean and ships as I did as a young boy. I am convinced that my love for the sea and my early years learning to sail had a profound and very positive influence on the direction of my life.

AOPS under construction at the Irving Halifax Shipyard


Kevin McCoy with his family at a boat show

John F. Newton
Rear Admiral, Royal Canadian Navy (retired)
Managing Director, Fleetway Inc. *(we fix ships)*

When I was young the sea seemed all around me. I lived and played on the shores of Bedford Basin, Halifax. My dad was a sailor who fostered in me a curiosity for what lay over the horizon. He taught me that sea lanes connected my world to places like the Pyramids of Egypt, the jungles of the Amazon River, and glacial fjords in the Arctic.

There was a book I devoured called *Men, Ships and the Sea*. It depicted the awesomeness of the ocean in photographs and art, telling the story of humankind's relationship with the sea through exploration, trade in boats, harvesting of seafood and sadly even the pursuit of conflicts at sea. Another book was *Nansen's Farthest North*, the tale of an explorer who drifted in his small ship entrapped in the Arctic ice to see if the winds and currents would push him to the North Pole. It expresses our desire to explore the mystery of the oceans that even today barely reveal their secrets.

And finally, in my home hung an ominous painting entitled Women and Children First. It depicted a shipwreck in the age of sail that highlights that work at sea is a challenging endeavor.

For 35 years, I worked on the oceans of the world, respected the power of the sea, was wowed by the science of oceans and climate, and never stopped learning and discovering. I believe that Canada is a great maritime nation and has an important voice in everything to do with the world's oceans.

John F. Newton when he served in the Royal Canadian Navy

Hannah Vaughan training in her kayak.

Hannah (far left) with her teammates at the 2015 Canada Games in Toronto, Ontario. Photo: olympic.ca/team-canada/hannah-vaughan

Hannah Vaughan
Canadian National Team Kayaker (retired)
Senior Communications Specialist,
Irving Shipbuilding

My whole life has been spent in, on, and around the water. Growing up in Nova Scotia, I have so many fond memories of playing in the ocean, ducking in and out of the waves. Later, as a national team paddler, I spent hours upon hours in a kayak, propelling myself across countless bodies of water. Whether at home, at training camp, or travelling all over the world to race for Canada, I always find myself drawn back to the ocean. I would train and compete on lakes, rivers, and canals, but if I need to relax, I'll find my way to the ocean. Watching the waves roll in and out is calming and peaceful, and always brings me back to my childhood.

After spending over 20 years kayaking, I've traded in my paddle for a pen. Now working in communications for Irving Shipbuilding, I have the pleasure of telling the stories of our 2,000+ shipbuilders who are building ships for Canada. Knowing that the work done at Halifax Shipyard will support the Royal Canadian Navy on oceans around the world for decades to come makes me immensely proud.

HOW I SEA THINGS...

Photo: Nova Scotia Sea School, 7-day Coastal Sailing Expedition

-Liam Oland, 19

Before I had gone on my first ever Sea School trip, I wasn't very keen on trying new things and putting myself out there. But by experiencing the teamwork, comradery and, at first, hard work that comes with Sea School, I recognized that throwing myself into new situations was not only great fun, but also a healthy way of expanding your own boundaries and learning about the world and about yourself. I made some lifelong friends and had experiences that have taught me some very valuable lessons.

Sea School will always hold a big place in my heart and I encourage anyone to best their hesitations and fears to try new things and just go for it!

MARINE SUDOKU

Here are two sudoku puzzles to try to solve. One is trickier than the other – ask a sibling, parent or friend to help you get started.

Complete this sudoku using the letters from the word **m-a-r-i-n-e** instead of numbers. You may only use each letter once in each coloured square, in each vertical column, and in each horizontal row.

A			I	N	
M			A		
N		E			R
R		I		E	A
					I
	R		E	M	

THIS ONE'S MUCH TRICKIER. STRETCH YOUR BRAIN WITH 9-BOX SUDOKU!

Complete this sudoku using the letters from the word **s-e-a u-r-c-h-i-n** instead of numbers. You may only use each letter once in each coloured square, in each vertical column, and in each horizontal row.

Check your answers

			R	I			E	N
I	R			U		H		
		A			S	R	I	
S	I	U		N				
H			I			S		
		R	H	S			U	I
	E		C				S	
				H	I		R	
	S		U			C		H

HOW OCEAN OBSERVATION AND CONSERVATION SUPPORT A SUSTAINABLE BLUE ECONOMY

A MESSAGE FROM THE CANADIAN OCEAN LITERACY COALITION (COLC)

As an environmental educator who has had the good fortune of teaching and learning on the water, from the Heiltsuk Nation of Bella Bella, British Columbia, to the Arctic and Labrador, to the Great Lakes and shoreline of the Ottawa River, I have witnessed firsthand that the most effective learning takes place through experience. We learn about the ocean – water or nature more broadly - by being on, in or around it. We also learn about the ocean through people who have spent their lives working, studying, and living on or by the ocean. However, getting to – or on, or in! – the ocean is not possible for everyone, nor desired.

Lisa (Diz) Glithero

This is where COVE's new learning resource leads the way. ***Wave of the Future: Canada's Sustainable Blue Economy*** weaves together clever and engaging information, personal stories, hands-on activities, and extended learning resources and opportunities for kids, families, and teachers.

Small cove off the coast of British Columbia

Fishing shack off the Atlantic Coast

Canada is an ocean nation, with the longest coastline of any country in the world. This coastline is characterized by diverse communities and cultures, all holding varying relationships with the ocean. Whether we live in a coastal region, or are among the 80% of Canadians who live inland, the ocean connects us all. It is a major driver of our economy, a rich food source, the backbone of our weather and climate systems, and so much more. We need a healthy ocean to ensure the well-being of all living creatures, now and for generations to come. We also need a young generation of innovative thinkers pursuing 'blue' and 'green' careers of all kinds to ensure a healthier, more sustainable, and just path forward for all.

Iceberg floating off the coast of Newfoundland

This dynamic learning resource contributes to this collective effort, challenging all learners, young and old, to think about the ocean and the consumer, as well as career choices that we each make. Together, let's ride the Wave!

Lisa (Diz) Glithero, PhD

National Coordinator, Canadian Ocean Literacy Coalition

HOW I SEA THINGS...

- Rhiannon Moore, Ocean Scientist, Vancouver

Although it was always there, the personal connection I felt with the ocean actually didn't begin until I was in my early 20s. I grew up in Ontario and was more exposed to freshwater, not saltwater. But then I went to British Columbia (Haida Gwaii) for a field semester. I learned so much about the interconnectivities of the marine landscape. The more time I spent near the ocean and the more I learned about it, the more I cared and wanted to protect it. I eventually became a researcher in Vancouver, focusing on plastic pollution and how it affects remote arctic ecosystems.

HOW OCEAN OBSERVATION AND CONSERVATION SUPPORT A SUSTAINABLE BLUE ECONOMY

Ocean observation is an important part of the sustainable blue economy. We can observe the ocean at many different levels; from the surface, to the deepest darkest depths, and even the sea-floor. Observation helps us to understand the living things that live in the ocean, how our oceans are changing, and how these changes are impacting the creatures who live, feed and travel through the waters. Ocean observation also helps to track other human activities, above and below, which helps us to defend our waters against illegal activities (*like pirates*) or activities that put sustainability at risk (*like dumping pollution or overfishing or fishing of protected species like whales*). Finally, ocean observation helps us to understand the depths of the great ocean that we can neither see nor travel to.

Ocean scientist photographing whales in migration

Remote scientific research in the northern waters of Canada.

How much of the ocean have we already explored?

a. less than 4%
b. around 10%
c. roughly half of it
d. all of it, but we still have more to learn

Answer: a

ACTIVITY: BECOME A GREAT EXPLORER!

The history books are full of stories about great discoveries. And there are more incredible things to be discovered in the deepest parts of the ocean.

Like this angler fish – it might look like something that Hollywood dreamed up – but this is a real fish from the deep, who uses the light on his head to lure dinner into its mouth.

What underwater worlds, or amazing creatures might you find? Use your imagination, and any artistic medium you like (*painting, drawing, animation, descriptive writing, etc*), to create an underwater world, or a creature of the deep ocean. Share your creation with us here.

Rendering of the deep sea angler fish / Photo: animalhype.com/fish/angler-fish

Divers exploring the coral and vegetation on the ocean floor.

An underwater cavern

In a conversation with Mi'kmaq Elder Albert Marshall, he shared some thoughts on what the ocean means to the people of this planet.

What is the ocean for? It's the original source of life. It's our thermometer, helping to regulate the earth's temperature. It's food and sustenance. It decides how weather patterns will unfold. It abides by the laws of nature. And it plays a big part in our understanding of why we are here. It's a gauge of the health of our planet – lately it has been a reminder that if we take selfishly from the ocean, there is a cost. When we see pollution in the ocean, and damage to her ecosystems, we are reminded that our rights as people do not come before nature's rights.

What distinguishes us from the animals on this planet is our cognitive mind. This has allowed us to transform the natural world. Now we need to use our powerful minds to imagine better ways of interacting with our planet, of caring for our home rather than destroying it, and of leaving it in better shape for future generations, than how we found it.

WHAT DOES OCEAN OBSERVATION MEAN?

Like any environment, we can use our senses to observe the ocean. We can see, touch, smell, taste and listen to it. Knowledge holders in traditional cultures have relied for thousands of years on traditional ways of knowing about the ocean and other water sources. They relied on their senses, on their memories of how things happened in previous years, on stories shared and passed down, and on the observations of others around them. This helped to reveal patterns, and helped communities to make predictions about, and understand the water systems around them.

But when we start to explore the deeper parts of the ocean, far beneath the surface and far from shore, we find that our senses don't work as effectively. In addition to our own senses, we also use instruments, like sensors and probes, that help us to see and hear and touch in places where we can't do so with our own eyes, ears and hands.

Estimate how much of the Earth's surface is covered by the ocean?

a. 20%
b. 50%
c. 70%
d. 99%

Answer: c

Ocean Observing

Contributed by Brendal Townsend,
Senior Operations Manager, Ocean Tracking Network - Dalhousie University

The ocean is so vast that it covers roughly 70% of the Earth's surface. This is why it is often referred to as the blue planet. And from its coastal areas down to its deepest depths, the ocean supports an abundance of life and diversity. Continuous monitoring of the ocean's health has never been

more critical, as we experience rapid climate change and the impacts of human developments on the marine environment. Today, we have a unique range of ocean observing tools that help us to understand the effects of a range of marine challenges, such as sea-level rise, ocean acidification, species loss, and the increasing intensity and frequency of storms.

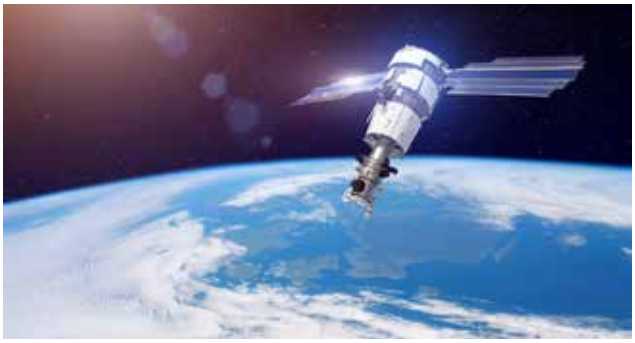
Humans are not at home in the ocean, and so we depend on a variety of tools to help us know what is happening. Ocean observation tools can help researchers track, predict, respond, and adapt to changes in the environment.

There are three primary ways that we can observe the ocean:

1. In the water (*in situ*)

2. Airplanes and drones can also be used to collect ocean data. In fact, most ocean pollution detection is done from airplanes.

3. From space (*using satellites*).



In-water observations include fixed or mobile platforms such as moorings, buoys, profiling floats, ocean gliders, divers and more. These instruments can be used for many things like, animal tracking, measuring sea surface temperature, currents, and salinity.

The other form of observing the ocean is with satellites. These remote platforms travel high above the Earth's orbit, and are able to sense ocean temperature, the presence of algae, wave patterns, and much more on scales that humans could never see from the surface of our planet.

For example, images taken by the satellites provide large-scale coverage of coral reef habitats and allow us to measure the areas being bleached annually by increasing sea temperatures. Satellites also carry a transmitter, that can talk to receivers on the ground, relaying important information such as the location of a lost person at sea.

These observations allow us to make better-informed decisions on managing the marine environment. Measuring sea-surface temperature and ocean acidification, helps scientists to better understand the warming of the oceans.

This information is important because warming waters can change the behaviour of fish, cause intense hurricanes, or impact the health of coral reefs, which ultimately affects all of us on the blue world on which we live.

Satellite image of coral reefs at Biscayne National Park, Florida / photo: NASA

USING TECHNOLOGY TO EXPLORE THE OCEAN

ROV stands for "remotely operated vehicle". These are underwater, unmanned robots, and there are many different types. ROV's are fantastic for observing the oceans. They are typically equipped with specialized sensors and high definition cameras. Many have manipulator arms and baskets to hold samples collected during missions.

Scientists can use ROVs to explore the sea or other far reaches of the ocean, with the operator remaining safely on a vessel at the surface while the machine does its work.

Human scuba divers cannot generally exceed 100m depths due to water pressure, the amount of air they can carry with them, and the risk of having gas dissolve in their blood and cause a disease called "the bends" when they surface. In contrast, ROV's can reach the deepest depths of the ocean, and can stay for very long periods of time to work. ROV's can range in size from micro ROV's (*weigh less than 3kg!*) to the size of a small car (*3200kg!*).

Underwater robots are usually tethered directly to a surface vessel and are controlled by a human pilot who sends commands down the tether. Some can be launched from a submarine or other, larger ROV. However, being attached by a cable limits how deeply or far ROV's can explore. For really deep operations, typically an AUV (*autonomous underwater vehicle*) is used. Autonomous means they can move around without direct control from a human at the surface, using a pre-programmed mission path and knowing where they are based on sound beacons and bottom tracking. The latest ones even alter their path all by themselves based on what they are finding with their sensors.

Video showing ROVs in the water - courtesy of Deep Trekker Inc.

There are many thousands of AUVs already being used already in offshore oil and gas, military, science, and recovery. For example; the hunt for the crashed Malaysian Airlines plane in the Pacific was conducted by Kongsberg AUVs with no cable control from the surface.

AUV's are a very exciting and important part of the future of ocean observation because they are not limited to a tether and can function with more mobility, allowing them to undertake new, far-reaching deep sea missions.

ROV detail / image: Ocean Tracking Network

Primary uses of the ROV include:

Exploration and Science –
Scientists use the ROV to study the ocean bottom, capture images of rare deep-sea creatures, or search for lost ships or submerged ancient cities. The robotic arm can also collect specimens and cut ropes on lost equipment.

Operations and Maintenance –
Industries such as aquaculture and offshore oil and gas utilize ROVs to capture images of damage to platforms, pipelines or fish pens and to help make repairs.

Search and Rescue Missions –
Police and fire departments use ROVs in search and recovery missions for people who have drowned or to recover submerged objects.

CAREER PROFILE: OCEANOGRAPHER

Conducting research on the water

My work is focused in the field of underwater robotics, where I design and build platforms to study specific phenomena, such as marine oil spills or algal blooms. Unlike existing commercial products, what I develop is open-source and low-cost, so it's widely accessible to those who need it, not just to those who can afford it. This work is perfect for me, as I get to use my engineering skills to address current problems that have immediate, real-world impacts. First and foremost, though, is understanding and identifying the problem, which is why I chose to do a PhD in science. In my lab, we've built a small but extremely talented and cohesive team of scientists and engineers, who work together to develop new and better technologies for observing the ocean.

Driving an ROV through the waves

Allison Chua, PhD Candidate, Department of Oceanography, Dalhousie University

Although I've lived in Nova Scotia my entire life and grew up paddling on the ocean, I didn't always plan on studying Oceanography at Dalhousie. I studied Mechanical Engineering in university, and before starting my PhD, I was working as an engineer in the shipbuilding industry. However, working in the deeply traditional and well-established business of naval vessel construction made me realize that I wanted to explore the use of modern technology to address current threats to our ocean environments.

Oil spill tracking with an ROV at the Ohmsett tank in New Jersey

This united approach is more important than ever, as we face unprecedented changes and challenges to our oceans that can only be solved by interdisciplinary teams working and sharing their knowledge with each other. To learn more, please check out my website: www.adozenautomobilesandkites.com

TECHNOLOGIES WE CAN USE TO OBSERVE AND CONSERVE THE OCEAN

Today, we have amazing technologies like fish tags that allow us to track the routes of marine fish (*like cod*), reptiles (*like sea turtles*), and mammals (*like dolphins and whales*). This information helps us to better understand where their feeding and mating grounds are, and their migration patterns. This information can also help to minimize whale strikes, as we can change transportation routes to avoid areas that are frequently traveled by whales. Being able to gather and share ocean data helps us all to build our understanding about the ocean and about our collective impact on the ocean. Observation data can help keep us safe on the ocean, and can help us to develop a more sustainable blue economy.

Technologies for Listening and 'Seeing'

Contributed by Joe Hood, Software Product Manager, GeoSpectrum Technologies Inc.

My job is to help people to see what is going on in the ocean. Cameras and radar don't work well underwater, so instead we use sound to "see". We do this with special devices called transducers that hear like a microphone and send out sounds like a loudspeaker, but they work best underwater.

Sound propagates (*travels*) better in water than it does in air, so even quiet sounds can be heard many miles away. Transducers can be used to quietly listen, with no one even knowing they are there. This works very well for things that make noise like boats or marine life. Marine mammals also know that sound is a great tool for seeing underwater so they make all kinds of cool sounds to communicate with each other and to hunt.

Listen to some whales, dolphins and other marine sounds captured using hydrophones in the ocean:

These are C-Bass transducers. They can make very-low-frequency sounds and can even play rock music into the water.
Photos courtesy of GeoSpectrum Technologies Inc.

People who want to see underwater use special software that turns sounds into images that help them decide what is making the sound and where it is. Transducers can also send out loud pulses of sound that reflect off of things before being received and processed in software that creates a picture for operators to see where they are. Tools for seeing underwater are used in all kinds of ways. For example, they can be used to watch whales, so we can decide how best to prevent them from being harmed. They can also be used to survey the ocean and decide which areas need to be protected and which can be safely and sustainably fished to provide food for people.

Ocean Sonics

It's important to listen to underwater events as they are happening. Real-time sound data helps us to better understand the environment, and it helps us make important decisions like slowing down vessel traffic to avoid collisions with marine mammals or pausing activities, like marine construction to prevent damage to fish and other marine animals. It can also hear and locate oil and gas pipeline leaks to help prevent environmental disasters.

There are also some cool sounds you can hear like glaciers cracking and falling into the sea, the sounds of marine mammals communicating to each other, earthquakes and footsteps on the ice.

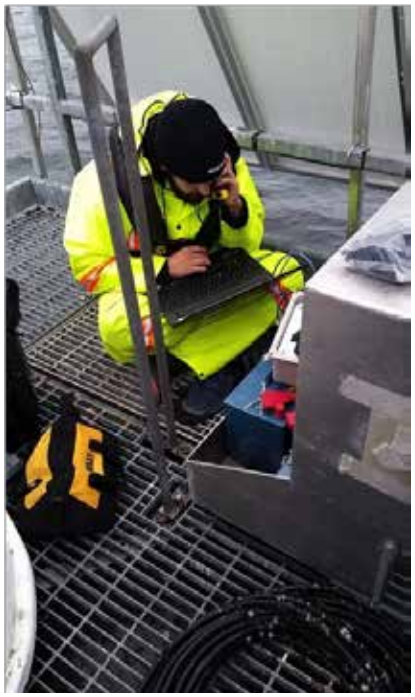
In addition to the giant transducers shown, we can also use hydrophones to listen in the water. The icListen is the world's first Smart Hydrophone.

It was created so everyone can easily listen underwater and use ocean sound data to make important and timely decisions. It even performs all of the difficult tasks for you, like making the calculations to process the data, and adjusting for different underwater environments and sounds.

A researcher deploying the icListen Hydrophone. Photo: Ocean Sonics

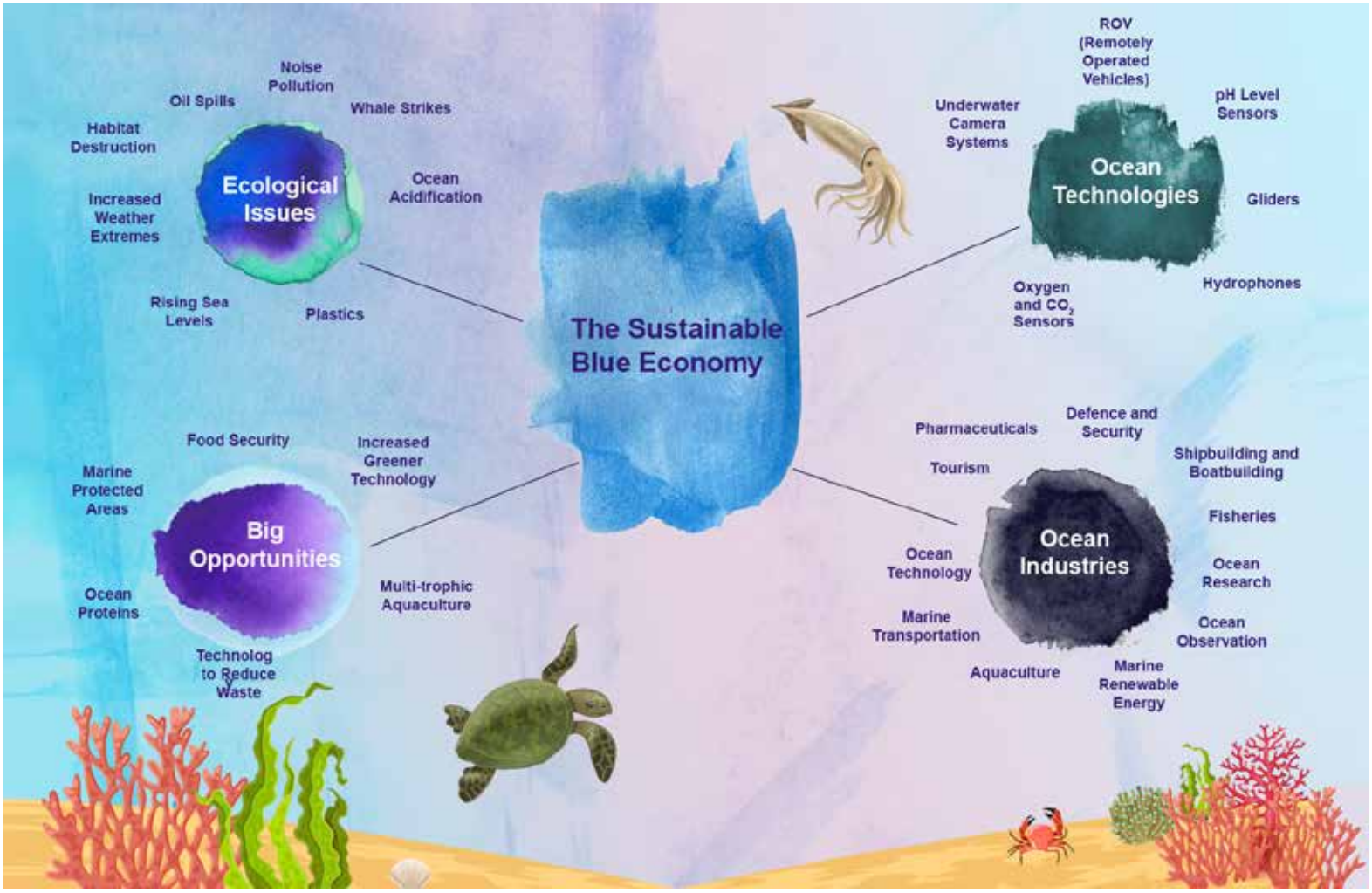
Photo: Ocean Sonics - an acoustic company based in Truro, Nova Scotia.

CAREER PROFILE: PRODUCTION TECHNICIAN



My name is Ben Cochrane and I was born and raised in Truro, Nova Scotia. My interest in electronics led me to the Electronics Engineering Technician course at NSCC Waterfront Campus in Dartmouth Nova Scotia. At the time I had no real plan in mind of where it would take me. During my time at NSCC I was introduced to the ocean tech business and I was instantly hooked. This seemed to be the perfect direction that combined my love of technology and nature.

When it came time to select a place for a work term, one of my instructors suggested Ocean Sonics. This is a small ocean acoustics company in Great Village Nova Scotia that designs and manufactures smart digital hydrophones. The hydrophones can be used for many things like marine research, environmental monitoring and renewable energy. There is even an icListen under the ice in Antarctica!



ACTIVITY: DESIGN AN INFOGRAPHIC

Choose an ocean issue, industry or opportunity that is important to you (*for ideas, have a look at the illustration above or choose another topic that might not be listed here*). Using your own knowledge and other information you find online, create an infographic to illustrate what is important about that issue, who it's important to, and how the sustainable blue economy can help.

STEP 1: Use Google Slides under your own Google Drive. Or use PowerPoint

STEP 2: Open up a new presentation, click File, then Page Set Up.

STEP 3: Choose Custom Page Set Up so you can put in your own dimensions. Put in 46.8w x 33.1h.

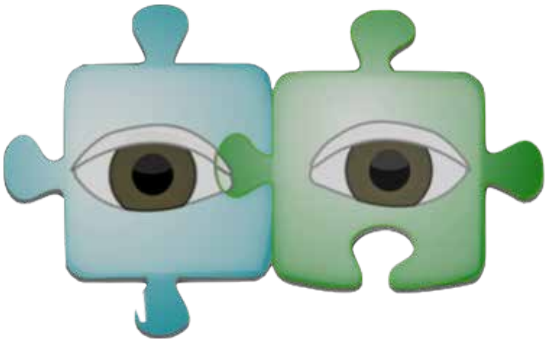
STEP 4: Click Apply. Now your slide will print on A4 size paper.

STEP 5: Design as you would like. When finished download either as pdf or picture! Share with us on Instagram @cove_workforce

TIPS

- **Download pictures for infographic as .png** – this means that the background of pictures is transparent
- **Find free icon downloads here:** https://www.flaticon.com/ **or** https://www.freepik.com/
- **To be able to grab icons and such**, a great place for google slide themes is to start here: https://filtergrade.com/free-google-slides-themes/

In a conversation with Mi'kmaq Elder Albert Marshall, he shared some thoughts on how we can use traditional knowledge along with 'modern science' to better understand how to use the ocean's bounty respectfully and sustainably.



Focus both eyes on an object in front of you. Now close one eye and look. Then close the other eye and look. The object looks the same, but also slightly different out of each eye. You're seeing that object from two related, but slightly different perspectives.

Two-eyed seeing compels us to think differently and to see from another perspective. It describes how we can take traditional ways of knowing that are based on touching and feeling, and seeing and smelling, and observing the world, with knowledge passed on from generation to generation, and pair that with modern, scientific knowledge, to have a holistic understanding. This combined knowledge will grow and evolve and change and will help us to co-exist with the natural world in a more balanced and harmonious way. When we see with just one eye, we can miss a lot!

IT'S GETTING HOT IN HERE! THE CHALLENGE OF A WARMING OCEAN

It's no secret that the ocean is warming up. Greenhouse gases in the atmosphere, like CO_2, trap the sun's heat, which is then absorbed by the ocean – warming it up. If you enjoy swimming in the ocean, this might seem like a good thing. But, a warming ocean is a concern for us all because melting icecaps can lead to a rise in sea levels which can lead to flooding. Warming oceans can cause coral bleaching which damages habitats and breeding grounds for many marine species. Warmer oceans have less dissolved oxygen, which makes it difficult for fish to breathe, but makes it easier for harmful bacteria and algal blooms (*who like CO_2*) to develop in the water. And, for people who live in cold climates, a warming ocean can make day-to-day life unpredictable or even dangerous.

Bleached branching coral (foreground) and normal branching coral (background). Keppel Islands, Great Barrier Reef. Photo: Wikipedia

SMARTICE, POND INLET, NUNAVUT
(https://smartice.org/)

For thousands of years Inuit people have relied on traditional ways of knowing to understand and make predictions about their environments. They looked, touched, smelled, listened, and shared their observations with others around them. Using decades of observation, Elders could predict where the ice was thick or thin, and where the ice was safe to travel upon. But even Elder knowledge can't keep up with climate change - and now people are falling through the ice because nature isn't following reliable patterns any more. Smart Ice combines traditional Inuit knowledge with information captured through modern sensor technology. This allows the Inuit people to capture reliable data about the rapidly changing ice – and keeps people safe. This is a great example of Two-Eyed Seeing to address a modern-day challenge.

Here's a link to more information about SmartICE

SmartQAMUTIK in action (pond inlet in background) / smartice.org

SmartICE Team interpreting radar imagery on the sea ice / smartice.org

Travelling across the frozen ocean just north of Pon Inlet, Nunavut / smartice.org

TEMPERATURE SENSORS

Temperature sensors are sensors that can measure the temperature of the ice, water or atmosphere. These sensors, and the data they provide, can show us changing patterns and trends in temperature, even before we see and feel the effects of a warming ocean. The ocean absorbs an incredible amount of the heat from the sun. The warming and cooling of the ocean affects weather patterns and ocean levels across the planet. So temperature sensors tell us more than whether or not it's a good day for a swim – they can help us predict things like storms and floods that happen above the waterline.

Glacier collapsing into the ocean.

CAREER PROFILE: OPERATIONS LEAD

As an Inuk from Nain, Nunatsiavut, the ocean has always been a part of my life - either by being in a small speed boat, or by travelling the sea ice on snowmobile.

Safety, especially on the sea ice, is becoming more and more unpredictable. Working with SmartICE as the Nunatsiavut Operations Lead is a way to help keep Inuit safe in and around my home community. Many of us travel over the sea ice either to hunt, fish, get wood to heat our homes, or to travel to our cabins. The sea ice helps keep our Inuit traditions alive. My position allows me to train local Inuit youth. We provide them with transferable employability skills. Ultimately, we train them to build our SmartBUOY stationary ice measuring sensors, which we can ship anywhere in the Arctic. In my role as Nunatsiavut Operations Lead, I get to travel to other Inuit communities across the North, helping to deploy our equipment and training locals to use our technology. In turn, they are helping to keep their communities safe too.

For me, the greatest satisfaction comes from knowing that my work is contributing to my people's safety and helping to keep Indigenous communities and traditions alive and well.

Rex Holwell, Northern Production Lead.
SmartICE Sea Ice Monitoring & Information Inc.
www.smartice.org

Left: Rex Holwell and the Smart-BUOY

Right: The SmartICE production team.

Photos courtesy of SmartICE

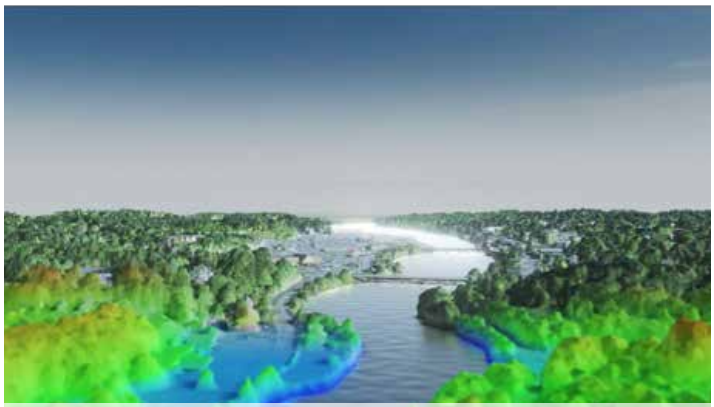
Detail of frozen sea ice showing the different thicknesses and textures.

HAPPENING NOW: TECHNOLOGY AT WORK

Contributed by Noah Stevens

3D Wave Design is an Indigenous-owned and operated company. Some of the first projects we worked on were for Mi'kmaq communities here in Nova Scotia. As members of the Acadia Band ourselves, helping the environment is very important to us. We hope that this technology can be used to help others understand and care for the environment too.

3D Wave Design is building technology that helps people understand the effects of climate change through interactive 3D maps. It can be hard to visualize scientific data that is represented in charts and graphs. It's vital that people who are making important decisions, like town mayors, municipal planners and emergency management officials, understand what the data means. Our job at 3D Wave is to take the data from the scientists and engineers, and display it in a 3D environment; much like a video game.



3D rendering of possible flood effects on the landscape.

So when a report talks about flooding of 2.7 meters, you can actually see what it'd look like!

Helping people understand sea level rise is very important, because many of us who live in coastal communities will be impacted. However, there can also be flooding inland as well. Have a look at the image below and see if you can detect the impact of floods on the community shown.

Aerial 3D rendering of possible flood effects on the landscape. / Photos: 3D Wave Design

HAPPENING NOW: TRACKING TECHNOLOGY

Contributed by Xeos Technologies

Our company is called Xeos Technologies and we are based in Dartmouth, Nova Scotia. We make all sorts of things that track buoys, underwater robots, surface drifters – and a new device that measures waves! We call it the Brizo. It's named after the Greek goddess Brizo who was protector of mariners, sailors and fishermen.

Our device is small, about the size of a football and goes right on top of a buoy. It sits on top and sends signals up into space to GPS satellites and the satellites send signals back. Using these signals, the Brizo can tell how big the waves are, what direction they are moving in and more. We use the same GPS that is in your cell phone or car to measure waves! This data is sent out to your email anywhere in the world.

We use this information for many things:

- tell ships whether it is safe or not to enter the harbour
- to monitor waves at fish farm sites in the ocean
- to tell technicians working on offshore wind farms whether it is safe to work or not
- predict storm conditions close to shore

We are still learning who else can use this technology to benefit their work in ocean science and ocean conservation. There are some in the Halifax Harbour here in Nova Scotia, 2 in Galway, Ireland and many more in Scotland, the UK, and Italy! People all over the world use the same technology to measure waves and observe the ocean. Some day we hope to have you onboard!

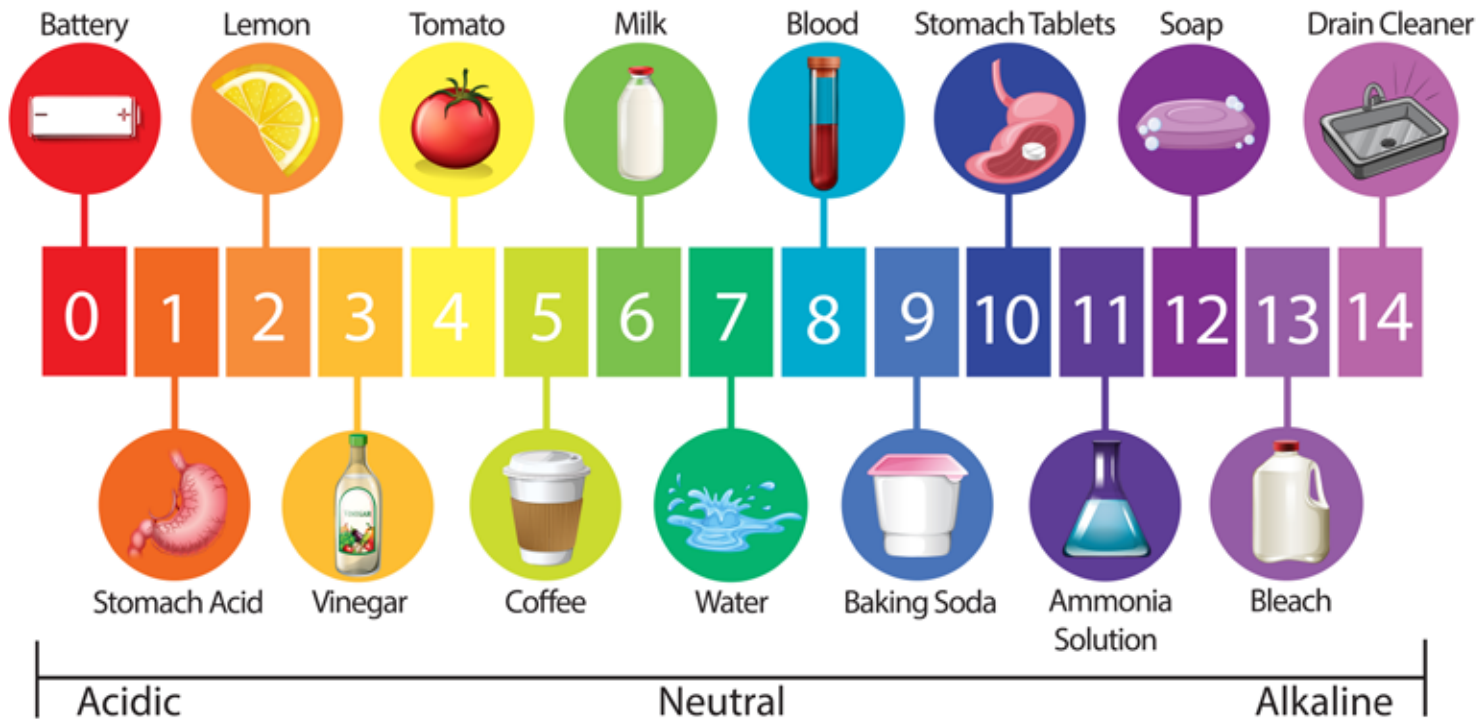
Installing a tracking device on a buoy. / xeostech.com


Buoy floating in the open ocean to monitor storm conditions

FROM ALKALINE TO ACIDIC: THE CHALLENGE OF OCEAN ACIDIFICATION

pH tells us how alkaline or acidic something is. Our tap water is generally considered neutral – or 7 on a pH scale. Lemon juice is quite acidic, with a pH of 2, and bleach is extremely alkaline with a pH of 13. Products at either end of the pH scale are toxic to living things. For plants and animals who live in the ocean and other waterways, even slight changes in pH can have huge impacts on their health.

The pH Scale:



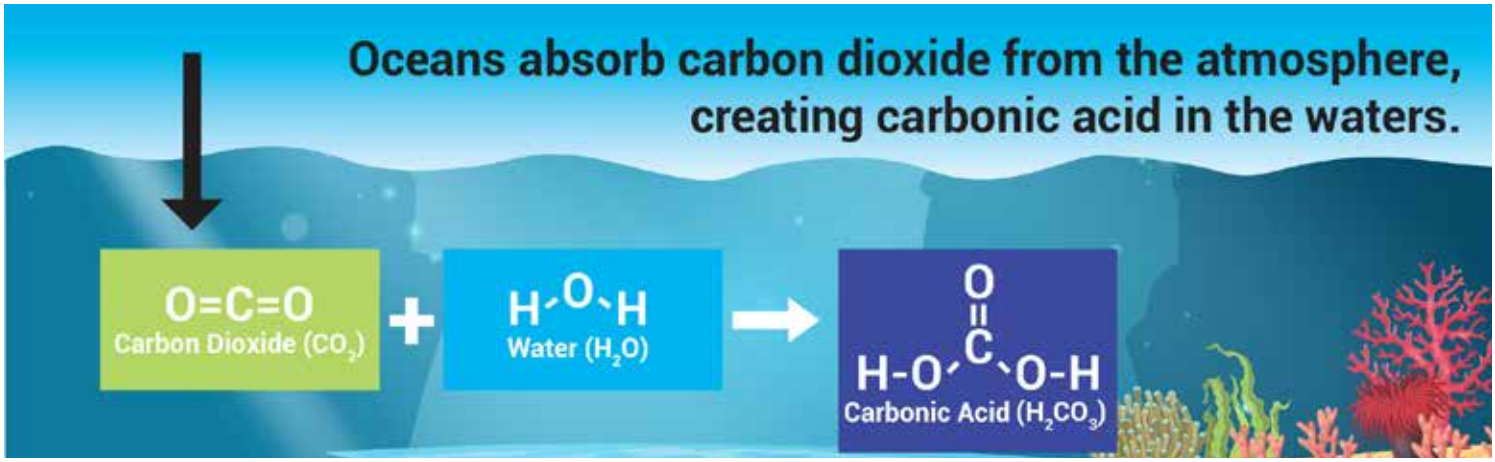
Have a look at the pH scale above. What pH do you think the ocean is naturally at?

It might surprise you, but the ocean is not pH neutral! For millions of years the ocean maintained a slightly alkaline state, with an average pH of about 8.2. That's roughly the same pH as our blood. Today, the average ocean pH is about 8.1. This might not seem like much of a difference, but the relationship between pH and acidity is not direct. Each decrease of one pH unit is a ten-fold increase in acidity. This means that the acidity of the ocean today, on average, is about 25% higher than it was during preindustrial times.

How is the ocean becoming more acidic?

Most of the marine plant and animal species that we are familiar with can tolerate a pH between 6 and 9 fairly well, but they are usually stressed by pH outside this range. Stress in a fish or marine plant can cause less growth and reproduction, and greater susceptibility to disease. Beyond this range, most species will die quickly. The optimum pH for most species is between 7 and 8.5.

Ocean acidification is mainly caused by carbon dioxide gas in the atmosphere dissolving into the ocean. A chemical reaction occurs when carbon dioxide mixes with water – creating carbonic acid! Over many years this leads to a gradual lowering of the water's pH, making the ocean more acidic. Use this QR for more info from the EPA:



Ocean acidification is important in the aquaculture industry because it can affect any animal that has a calcium carbonate exoskeleton, like sea urchins, mussels, clams, oysters – causing their shells to dissolve. This means that they must spend a lot of their time and energy repairing their homes, rather than using that energy to grow or reproduce. This can affect yields for aquaculture crops for farmers, and food supply for a growing population that relies on seafood.

Carbonic acid steals the carbonate needed by some marine organisms for their shells – causing their shells to dissolve.

ACTIVITY:

See the effects of ocean acidification in your own kitchen.

An egg shell is made of calcium, just like the shells in the ocean. Try this experiment to see the effects of acidification on a shell.

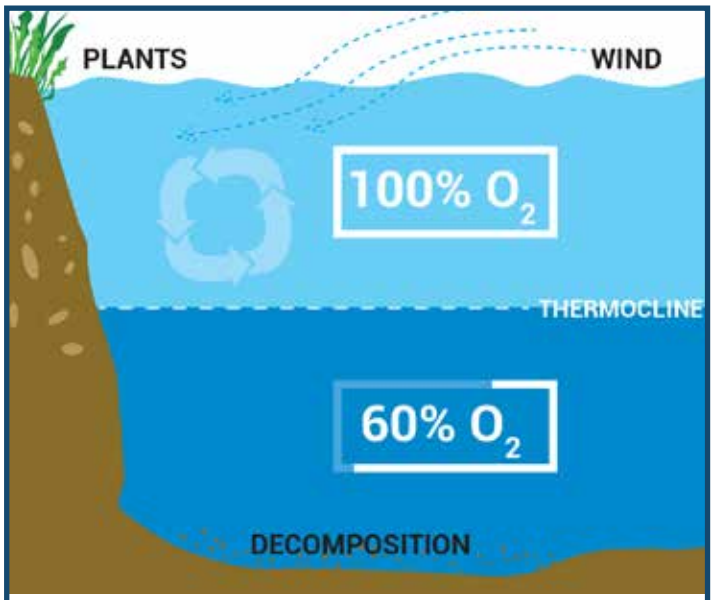
What you need: a hardboiled egg, a glass mason jar or big measuring cup, regular vinegar from the kitchen cupboard.

What to do:

- Put a hardboiled egg into a glass jar.
- Fill the jar to cover the egg with vinegar.
- Leave it be for several days.
- Make your observations each day:
  - What effect is the vinegar (*an acid*) having on the egg shell?
  - How long did it take?

What can you learn from this experiment about the effects of ocean acidification on various shellfish who live in the ocean?

WATER, WATER EVERYWHERE AND NOT A DROP TO BREATHE



This diagram shows a balanced and healthy oxygenation cycle of the water. When there is more CO_2 present in the water, there will be less room for oxygen and therefore less available for underwater life.

CO_2 SENSORS

Pro-Oceanus Systems' dissolved carbon dioxide sensors are used to help researchers measure the changes occurring in our oceans and waterways that are resulting from climate change and human activities. Understanding these changes and how they affect critical ocean ecosystems is a challenging task made easier with rugged equipment designed for the harsh and unforgiving seas. These sensors monitor the small, but important, changes occurring in our oceans. Water with high CO_2 can dissolve the shells of shellfish, making these creatures less likely to survive.

Monitoring carbon dioxide in the water is also vital in ensuring the health and well-being of fish in aquaculture. Much like us, fish require oxygen to breathe, and high CO_2 levels can reduce a fish's ability to breathe. Measuring water quality in aquaculture allows for changes to be made when needed, and helps to create strong and successful fish.

Well, after reading about ocean acidification, you know one reason why it's important to be able to monitor CO_2 levels in the ocean. But there's another important reason. Think about the creatures that breathe underwater. They are breathing oxygen that is dissolved in the water. As the ocean gets warmer the water can hold less dissolved gases. That means that when more CO_2 dissolves into the ocean, less oxygen can dissolve into it – which makes it hard for marine creatures to breathe. This is called ocean deoxygenation.

Researchers using a sensor to measure levels of CO_2 in the tropical ocean. Photo courtesy of Bayani Cardenas

Deployment of sensor platform in Cambridge Bay, Nunavut to monitor under ice. Photo courtesy of Ocean Networks Canada.

OCEAN OBSERVATION AND CONSERVATION THROUGH STORYTELLING

The Capelin Roll - A modern-day fable - inspired by a conversation with Elder Albert Marshall

One day, two young kids were sitting on a rocky beach in Labrador. They were visiting the area for their family holiday, and today they were hoping to see whales breeching off the shore. For an hour they had been waiting patiently, searching the horizon for the telltale spray of a whale exhaling as it surfaced, but so far, they'd seen nothing but seagulls.

They noticed an older man on the beach who had crouched down to investigate something. The pull of curiosity drew the kids to the man to see what had caught his attention. As they drew closer, they noticed the beach seemed to be moving. Tiny silver, shining bodies were writhing on the beach.

"What is that?!," gasped one of the kids.

"They're capelin", the Elder said.

"They're gross!", one kid shrieked.

"Look again," said the Elder.

The kids crouched down for a closer look. Thousands of tiny bodies were wriggling on the pebbles of the beach, spinning and rolling as waves deposited more fish onto the beach, and drew more back into the ocean with each ebb and flow. Their silver bodies reflected a dazzling rainbow sheen.

"It's the capelin roll," the Elder remarked.

"Why are they here?", the kids inquired.

"They're here to spawn," the Elder replied. "They come each year. And each year we celebrate their return."

The kids poked the tiny bodies with their fingers and asked, "Why would you celebrate these fish? They're small and boring. Not like whales."

The Elder smiled and said, "Look again. Look around you."

The children looked and they saw birds eating the fish.

The Elder continued, "they may be small, but they are food to many creatures of the ocean. Including the great whales. Without them, there would be no whales to spot."

At that moment a whale spout shot into the sky from the deeper waters off the beach. But the kids didn't notice. They were entranced by the spectacle of sunshine reflecting off a rolling silver wave of capelin that was surging and swelling its way along the beach.

See the capelin roll for yourself in this video!

ACTIVITY: A MODERN-DAY FABLE

A fable is a short story that teaches a lesson. Write your own modern-day fable relating to how we appreciate, learn from or treat the ocean and other waterways. Share it with us on Instagram as a written story, or as a video: instagram.com/@cove_workforce

OCEAN OBSERVATION AND CONSERVATION IN THE VIRTUAL WORLD

What do you get when you combine teachers, ocean scientists, and film makers? **Ocean School**! Ocean School is a free online education resource that helps students learn about the ocean. They use videos and other digital content to join scientists who are studying the ocean, businesses that work in the ocean, and communities that depend on the ocean. These stories and activities help students learn firsthand why a healthy, and sustainably used ocean is so important for businesses, communities and the environment.

So, what role does an organization like Ocean School play in the blue economy?

Education: Ocean School resources strengthen student's knowledge of core concepts in science, math, the arts, history, and geography (*among many others!*). Check out this virtual cod dissection for an example of the type of activities created in Ocean School.

Education and conservation at Ocean School

Career Exposure: Ocean School helps youth learn about the many different types of ocean careers they could one day pursue. This is important for building a workforce for the many businesses and organizations in the blue economy. For example, you can take a 360° video tour of an oyster aquaculture farm, or join fishers off the coast of Newfoundland as they use sustainable fishing methods to catch cod.

An Ocean School video production about conservation

Conservation: Ocean School helps the public (*and youth in particular!*) better understand how they affect the ocean, and how the ocean affects them. This is important for inspiring people to be mindful about how their actions impact the ocean. See how one of the Ocean School youth hosts took action to help conserve the ocean by scanning below:

Ocean School is a great example of how people from very different areas of expertise can contribute to the blue economy. Their team includes scientists, science communicators, educators, education technology specialists, computer programmers, film makers, writers, graphic designers, animators, and game designers among many others. It's this combination of artistic creativity, technical know-how, and science education that makes Ocean School work. Visit them at www.oceanschool.ca to learn more!

CAREER PROFILE: CAMERAMAN AND VIDEO EDITOR

Contributed by Théo Belnou
Ocean School Cameraman and Video Editor

I was born and raised in France, far from the ocean. From a very young age I was passionate about photography and cinema and knew I wanted it to be my future career. As a videographer I shot different videos, including advertising campaigns for clothing brands, the process of making airplane landing gear, even a self-sufficient community in Costa Rica. What's incredible about this job is that you never know what you will be filming!

I started filming ocean content by chance, when I joined Ocean School for one project. At the time, I didn't know much about it, but from the very first shoot I was immediately fascinated by the marine world and became a permanent part of the Ocean School team. Since then, I discovered the world of cod fishing in Newfoundland, the migration of salmon in British Columbia, the life of sharks in Costa Rica and even travelled aboard a submarine to a depth of 300 metres!

My job is filming 360-degree videos and virtual reality. Back in my studio, I edit the footage and work with the science team to find the best way to tell an interesting and cool story that looks good, but still make sure the science is accurate. Working with Ocean School made me aware of the importance of biodiversity and the impact of the ocean on our lives. My job has taken on another dimension, and thanks to my camera I can tell the stories about the ocean and help protect it.

Hear Theo talk about Ocean School and some of the interactive and virtual experiences they offer.

CAREER PROFILE: SCIENCE PRODUCER & COMMUNICATIONS OFFICER

Contributed by Lucija Prelovec
Ocean School Science Producer and Communications Officer

My name is Lucija and I LOVE the ocean! I grew up near Lake Ontario, over 1000 km away from the ocean. So where did this love come from? Well, I spent my childhood summers in Croatia, snorkeling in the Adriatic Sea. These summers made me realize I wanted to study marine biology and that's exactly what I studied at the University of Guelph.

I loved my time at university, I liked learning about ocean science but I realized I loved teaching others about the ocean more! So after university I worked at different aquariums, teaching all ages.

I decided to go back to school and study science communication at Laurentian University. I spent the year honing my communication skills, learning from experts, even building an exhibit for a science centre! The program helped open my eyes to how important good science communication is and the variety of ways to do it. Afterwards, I decided I needed experience teaching different types of science and I spent a year travelling across Canada teaching theoretical physics during Canada 150.

This was an unforgettable experience, but I missed teaching about the ocean! I went back to my roots, moved to the coast, and am now working at Ocean School. I work with an amazing creative team and together we use storytelling to communicate ocean science online in a fun and memorable way. I also find exciting ways to promote Ocean School over social media, and get to continue sharing my love for the ocean.

GET INVOLVED

Here are some more ways to get involved in the ocean, across Canada.

- **Check out the Ripley's Aquarium of Canada Live Cams**:

- **Ocean Wise** - https://seafoodedkit.ocean.org/ and https://ocean.org/learnonline/

SEA CADETS

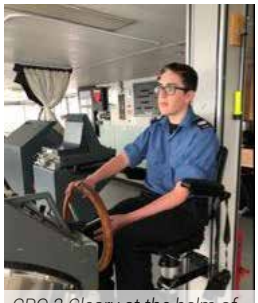
Contributed by CPO 2 Ben Cleary
https://navyleague.ca/royal-canadian-sea-cadets/

Sea Cadets, in my opinion, is one of the most rewarding and valuable programs that I could have ever experienced. Not only is it completely inclusive and open to everyone, but the amount of opportunities the program presents to youth in our community is immeasurable.
Through Cadets, you have the chance to make life-long friends, learn new skills through weekly workshops, experience independence and responsibility through deployments, and attend summer training programs. Through my years in cadets I had the chance to participate in four summer training programs, travel to Ottawa, be deployed aboard Canadian Coast Guard Ship Louis S. St-Laurent in the Arctic for six weeks and was selected to travel to England to sail aboard the Tall Ship Royalist.

Throughout my years in cadets I've not only learned things like how to safely operate vessels of all sizes, how to be an effective team member and leader, and many other useful skills that I will use in life; but I've learned a lot about myself and it has definitely helped shape me as a person.

Currently being a senior in my corps, I am sharing the knowledge I have gained by mentoring and instructing younger Cadets. I personally plan to continue to stay connected with the ocean by joining the Royal Canadian Navy after I have finished university; where I plan to study Oceanography and Marine Biology. Each of these experiences would not have been possible without participation in the Cadet Program.


CPO 2 Cleary enjoying being on the ocean.


CPO 2 Cleary at the helm of CCGS Louis S. St-Laurent

- **Huntsman Marine**
  Saint Andrews by the Sea, New Brunswick

If you're in the east coast, why not stop by the Huntsman Marine Science Centre? It is a not-for-profit organization located at the mouth of the Bay of Fundy. It brings together a unique combination of educational opportunities and research expertise to promote a better understanding of Canada's marine environment. The goal of the Education Department is to foster in students a lifelong interest in science, by showing them that it can be fun to learn scientifically, though "hands-on" activities. All Huntsman programs give students essential field experience to help them understand the delicate balance of marine ecosystems. What students collect, from the seashore or research vessel, is what they will study in the lab. A unique schedule is set up for each visiting school/group around the times of low tide. Time-tested and proven approaches guide by experienced Huntsman staff provide participants of all ages with a memorable education experience.

Urchins and crabs in an aquarium habitat / Hunstman Marine

Holding a crab / Hunstman Marine

BACK TO THE SEA

Back to the Sea is a charity dedicated to sparking curiosity for marine life and inspiring a desire to protect our ocean.

Experiencing the fun of the Touch Tank Hut in Dartmouth, Nova Scotia / backtothesea.org

They operate the Touch Tank Hut, a miniature marine interpretive centre on the Dartmouth waterfront. The Touch Tank Hut features local North Atlantic intertidal species that visitors of all ages can gently hold and view up close.

Back to the Sea also offers portable touch tank events and a family friendly field trip series called Tidal Trekkers. On their website, you'll also find a variety of free online education activities, including a Shell & Tell video series, trivia and colouring sheets. Back to the Sea's ultimate goal is to open a permanent community aquarium in the Halifax area.

Learn more: http://www.backtothesea.org/

HOW I SEA THINGS...

- Arianne Tremblay, 19, Baie Comeau, QC

When I was younger, I had a vision of the ocean as the unreachable place, a dream place. I remember seeing it depicted in films as the ultimate quest in which only enormously courageous people could overcome the raging waters that absolutely did not want humans visiting. But what was it in reality? I didn't know. I was convinced, until I participated in the Students On Ice expedition in 2018, that I would never see the ocean in a real way, since I tended to associate it with danger and the inaccessible.

However, what I saw that summer was that, although the ocean has incredible power, it is discreet. It rages at times, just like human beings, but I fell in love with its peaceful side.

The ice crackling gently to the sound of the rain, a shy whale performing when it knew there was nobody to watch except a few curious eyes, a sudden din from a glacier detaching from the floe... then a return to calm, silence, feeling tiny in this ocean that only asks you to respect its beauty, its tranquility, its environment.

The best I can say is that, not only did the ocean create one of my best memories, but it also let me invent my own version of it for the film about my short existence thus far. And you know what? I prefer that version to any film on the market, since it brings me serenity.

QUIZ YOURSELF

1. An ROV (*remotely operated vehicle*) can be used for which of the following activities;

- ☐ a. to capture images of rare deep-sea creatures
- ☐ b. to collect specimens and cut ropes on lost equipment with a robotic arm
- ☐ c. to perform maintenance on aquaculture tanks, or oil and gas platforms and underwater pipelines
- ☐ d. to help with search and rescue missions
- ☐ e. all of the above

2. Two-eyed seeing means;

- ☐ a. doing research with both eyes open instead of winking each eye
- ☐ b. using information from different sources, like traditional knowledge and modern scientific data, to understand the world and make informed decisions
- ☐ c. refers to marine species who have two eyes on either side of their heads, like sharks
- ☐ d. refers to marine species who are able to look in two different directions at the same time

3. Approximately how much of the earth is covered by the ocean?

- ☐ a. 20%
- ☐ b. 50%
- ☐ c. 70%
- ☐ d. 100%

4. Each of the chapters showed us different ways that we <u>all</u> interact with and rely on the ocean and other waterways, including;

- ☐ a. we all breathe oxygen - and the ocean produces roughly half of the oxygen in the air
- ☐ b. we all buy and use food and products that travel to us on the ocean and other waterways
- ☐ c. we all experience the weather and temperatures that are regulated by the ocean
- ☐ d. all of the above

5. Which are <u>not</u> industries involved in the Blue Economy;

- ☐ a. Agriculture and Forestry industries
- ☐ b. Aquaculture and Fishing industries
- ☐ c. Tourism and Marine Energy industries
- ☐ d. Defense and Ocean Technology industries

6. Conversion rates refers to how many pounds (or kilos) of food is required to raise a pound (or kilo) of animal protein. We learnt in chapter 2 that fish have the most efficient conversion rates when compared to cows, pigs and chickens. Why is this?

- ☐ a. Gravity and Buoyancy
- ☐ b. Gravity and Thermodynamics (*how the fish keeps its body the right temperature*)
- ☐ c. The salinity (*saltiness*) of the ocean
- ☐ d. Dissolved oxygen and carbon dioxide in the ocean

QUIZ YOURSELF

7. The Nisga'a Nation refer to the Oolichan fish as the saviour fish. Why would a tiny fish like this be considered a saviour fish to a First Nation community like the Nisga'a?

- [ ] a. because its arrival signals that winter is over and the season of harvest of the tiny, oily fish has begun
- [ ] b. it's a sarcastic expression because small fish don't really matter in any ecosystem
- [ ] c. because Oolichans can swarm a shark and kill it to save their young
- [ ] d. because the Nisga'a Nation farm the Oolichans in land-based fishing pens

8. Which is <u>not</u> true about Integrated Multi-trophic Aquaculture systems (IMTAs)?

- [ ] a. they are designed to farm different species together that would naturally be part of a food chain
- [ ] b. they are designed so that one species provides food for benefit to another that is farmed together
- [ ] c. they are designed to be self-regulating and self-cleaning
- [ ] d. they are widely used across Canada because they are easy to keep in perfect balance

9. In chapter 3 we learnt about energy in the blue economy. Where does most of the energy in Canada come from that runs our day-to-day lives?

- [ ] a. Biomass and Geothermal energy
- [ ] b. Tidal energy
- [ ] c. Hydro energy from moving water
- [ ] d. Solar and Wind energy

10. Marine renewable energy from harnessing daily tidal energy is a terrific idea because it can generate more energy than other renewable forms. But it presents a huge engineering challenge for all these reasons <u>except</u>;

- [ ] a. it's unpredictable - we don't know when the tides will be or when or where they will be strongest
- [ ] b. we can't turn the tides off and on, so it's hard to get the tidal turbines into the water in the right place
- [ ] c. the tides are very strong, so it's difficult to keep the turbines in place
- [ ] d. engineers need to consider the marine life that will live or travel near turbines - after all, we don't want to injure the marine creatures' ocean home
- [ ] e. winter means ice - and ice can easily damage expensive equipment or carry it out to sea to be lost as ghost equipment

11. Which is <u>not</u> an example of a marine renewable energy source?

- [ ] a. offshore oil and gas
- [ ] b. coal
- [ ] c. offshore wind
- [ ] d. tidal

QUIZ YOURSELF

12. Most of the goods we buy have spent some of their time getting to us on the ocean or another waterway. These are all reasons why marine transportation is an efficient and sustainable option, except;

- ☐ a. low carbon footprint
- ☐ b. we can send things anywhere around the world
- ☐ c. each shipment can carry huge amounts of goods, making it a cheaper way to transport goods
- ☐ d. this is the fastest option for transporting goods

13. The warming of the ocean is a problem for all these reasons except;

- ☐ a. warmer oceans can absorb less dissolved oxygen which fish need to breathe
- ☐ b. warmer oceans can affect weather patterns that lead to more intense and dangerous storms
- ☐ c. warmer oceans attract more swimmers which make the ocean more crowded
- ☐ d. warmer oceans lead to further ice melt from the polar caps, which cause sea levels to rise and lead to flooding in coastal areas

14. This booklet was developed by COVE. What does COVE stand for?

- ☐ a. centre for ocean ventures and entrepreneurship
- ☐ b. centre for ocean voyages and excursions
- ☐ c. centre for old vessels and engines
- ☐ d. central oceanographic veterans' establishment

Check your answers

ACKNOWLEDGEMENTS

This book was not the work of one person, or even of two. It is an example of what happens when you tap into a network of dedicated industry people, innovators, entrepreneurs, educators, colleagues, community leaders, Elders and Knowledge Holders, and friends. Thank you to everyone who played a part, through contributions and ideation and network building, in developing this book.

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Special thanks go to Maria Gallaugher of Ink Bottle Design, for bringing all of this content to life with her creativity and imagination along with her wonderful desktop publishing skills.

And a final thanks to my mom, Heather Scully – who is still cleaning up after me – in this case, by editing the final version of this book, catching all the little mistakes I missed.

Dr. Sherry Scully swimming with nurse sharks, Belize.

Author: Dr. Sherry Scully, Executive Director COVE Workforce Initiative

The first time I saw the ocean in real life I was 9 years old. I had grown up hundreds of kilometers from the coastline but a family vacation took me to the beaches of the Pacific. I was nervous at first about stepping into the waves. I had seen enough shark movies to feel certain that the ocean was a deep and dark pool of biting teeth and stinging tentacles and slithering serpents. But, my curiosity won out over my imagination and I tugged on a mask and snorkel and bravely waded in.

I felt the pull of the tide at my feet drawing me deeper. I fitted the snorkel onto my face, squeezed my eyes shut, and dipped my face down for a first breath beneath water – and was surprised when my lungs filled with cool air. The snorkel worked! And then I opened my eyes…

I saw sea grass dancing slowly, I saw fish – so many fish – all around me. And what really struck me was the quiet. All I could hear were my own slow deep breaths. Bubbles floated gracefully past my face. I saw nothing scary. No teeth. No stinging tentacles. Nothing slithered. It was an aquamarine scene of calmness. It was a whole new world that I had never been aware of. And in that moment – I was hooked. I knew I wanted to explore the mysteries of this great water-world.

Content Developer: Anna Naylor, COVE

I once was asked to think about a place where I felt the most relaxed and at peace. Without hesitation, I knew it was being in the ocean watching and observing a whole other world. When you are underwater, you realize how small you are in the larger ecosystem. You see all the other animals and plants who have evolved to spectacularly survive in the ocean. You learn that the ocean holds so much history, science and opportunities and we have so much yet to discover! The ocean has always been my favourite place, and as I got older I knew I wanted it to be part of my career so I could share my passion about it and get others just as excited as me.

Anna Naylor doing a handstand while scuba diving