Where the Land Meets the Sea – The Nearshore.
A lesson plan about marine nearshores, and some of their inhabitants.

Acknowledgements
Ramona de Graaf of SeaWatch Society provided information and photos of forage fish for this lesson plan. John Buchanan generously provided photos and video footage of herring in Howe Sound.
DG Blair, executive director for the Stewardship Centre for BC provided assistance with Green Shores approaches to shoreline development and definitions of terms. Green Shores is a program of the Stewardship Centre for British Columbia

Parts of this Lesson Plan

1. Overview

Where there is transition in natural systems (ecosystems), there is an overlap in species from both ecosystems, plus some organisms that are unique to the area. These transition zones are called ecotones, and when applied to where oceans meet the land, are referred to as the nearshore, which includes the intertidal or foreshore zone, the subtidal zone (to a depth of 10 meters), and for this lesson plan, also the backshore zone.

In **Where the land meets the Sea** – **The Nearshore** - the shoreline ecotone will be explored, and through discussion, activities and explorations, the connections of land to sea will be investigated and key inhabitants of the area identified.

There are many creatures that utilize and rely on the shoreline ecotone for survival – whether for habitat for day-to-day living or transition to ocean life, reproduction of their species by using the area for spawning, or as a zone to visit for food when the opportune moment arrives. Some of the components of this diverse and interesting area that will be explored are eelgrass, (Zostera marina), and two of the forage fishes – Pacific Herring and Sand lance, which are nearshore spawners. Pacific herring spawn in the eelgrass just offshore, or on marine algae, and are a large part of our coastal history.

2. Supplementary Information

(this enhances both activities)

What is the nearshore? – This is a general term for the shoreline area that encompasses the foreshore (intertidal from the highest high tide to the lowest low tide) and subtidal zones (below low tide zone) to a depth of 10 meters. The backshore area to a height of 60 meters above the ordinary high water mark (OHWM) has also been included, as the impacts on the foreshore and subtidal zones from human activities in the backshore area are significant.

Impacts on the nearshore

The shoreline ecotone is an area of great interest to humans. It is an exciting and beautiful area, an edge, where the powerful elements of weather and ocean are most evident. This area is highly valued as a location for homes, lodges, resorts, camps, marinas, and parks.

With the introduction of human dwelling comes the desire for an unobstructed view of the ocean, the defoliation of backshore slopes for building sites, access, and parking, and commercial ventures.

Why is this a problem? The pressure placed on the nearshore can be immense. Dredging for adequate water depths for marinas can destroy eelgrass beds. Building close to the water's edge for the best view creates the need for protection in the form of cement barriers or rock walls which change the character of the beach.

What can we do?

Keep our shorelines natural – building walls of concrete or rocks intensifies the power of the incoming waves as they hit the hard surfaces, and the water then carries the sand and smaller sediments out to sea, leaving a rocky, cobble beach.

Keep the backshore plants – plants have an important role in keeping soils and sediments in place, not allowing the soil to be washed out to sea by high storm

waters or heavy rain storms. Trees and overhanging vegetation shade important smelt and sand lance spawning areas in the intertidal zone from the intense summer sun.

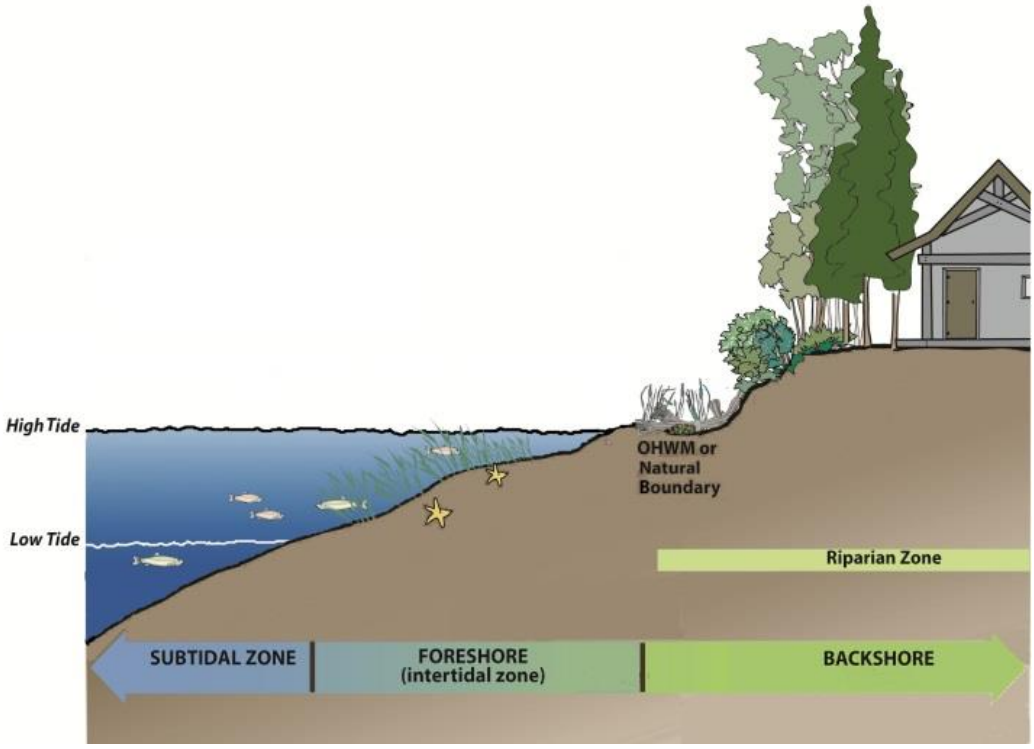


Figure 1. Green Shores for Homes Credits and Ratings guide 2015

What is Eelgrass –

Eelgrass is a true plant that lives just below the low tide level to approximately 10 meters depth in the marine environment. It depends upon the sunlight that penetrates through the water surface to manufacture its food via photosynthesis. Eelgrass grows by vegetative growth (shoots breaking off), by the spread of the mat-like rhizome roots under the marine substrate, and by seed germination. There are two species of eelgrass in the Pacific Northwest: Zostera marina (native species) and Zostera japonica (exotic species).

Eelgrass forms fringes, beds, and meadows that grow in sandy, muddy substrates, along shorelines below the low tide level, and in estuaries. These beds are a haven for crabs, a myriad of other marine organisms, numerous species of fish, and other wildlife. The long blades of eelgrass are often covered with tiny marine plants and animals called epiphytes. Here, a huge diversity of creatures find habitat, protection from predators, nursery grounds, food, and a safe migration corridor.

Facts about eelgrass:

- Eelgrass is not a seaweed (algae); it is a flowering plant which produces seeds and pollen.
- Eelgrass blades can grow up to 6 feet long
- Eelgrass was once harvested, dried, and used for insulation in houses, and has been used as packing material and stuffing for

mattreses and cushions.

- Eelgrass was even used to stuff seats in early models of Volkswagen!
- Eelgrass is a nursery. It provides shelter and protection for many juvenile fish and shellfish.
- Eelgrass was used by some First Nations as a food source (the leaf base and rhizome roots) and herring spawn on the leaves is still eat.

Eelgrass Fact Sheet:
www.gibsons.ca/include/get.php?nodeid=387

What are Forage Fish – Forage fish are smallish fish that are prey or "forage" for larger species, a key link in the marine food chain. As adults, they also "forage" for smaller food items (plankton) themselves.
Forage fish provide an important link between tiny plankton and larger fish, marine mammals, and birds. They provide food for many species. This is apparent in the feeding frenzies that result whenever schools of forage fish are present. Fish such as salmon, perch, and hake feed on the larvae shortly after they hatch. Seals, sea lions, whales, many larger fish including salmon, and numerous types of birds feed on adult forage fish.
The forage fish included in this lesson plan are the Pacific Herring, which spawn on eelgrass and marine algae, and Pacific sand lance which lay their tiny (0.5–1mm) eggs on gravel and sand beaches from Alaska to California, including the B.C. coast.

Facts about Forage Fish:

- **Herring** – Pacific herring (*Clupea pallasii*) grow to be about 15-25 cm in length.
- Fish, sea mammals, and birds rely on this fish and its eggs for food.
- Herring are considered a food fish for humans and are fished commercially. Once huge numbers have been reduced dramatically.
- Coastal First Nations use herring and their spawn extensively for food, and the Heiltsuk and other First Nations have been harvesting herring roe on the B.C. coast for hundreds of years.
- During spawning, herring attach their eggs to marine algae, eelgrass, and even pilings.
- Herring eggs are able to survive on the beach attached to seaweeds from one high tide to the next.
- Spawning happens from late January until May along the BC coast.

https://www.youtube.com/watch?v=D5NZGb-mRrQ&feature=em-share_video_user (herring spawning)

- **Pacific Sand Lance** – Pacific sand lance (Ammodytes hexapterus) are slightly smaller than surf smelt (up to 20 cm long).

- They live near the shore year-round and spawn on sand or pebbled beaches in the intertidal zone during the winter (November–February), often using the same beaches as the surf smelt.
- Sand lance make up at least 50% of the diet of adult Chinook salmon
- They are sometimes called needlefish.
- Sand lance are not fished commercially, but have been an important food source for First Nations for decades.

- **Surf Smelt** – Surf smelt (Hypomesus pretiosus) grow to be 20–25 cm long, and feed on small organisms.
- Smelt are part of the commercial and recreational fisheries.
- They are an important food source for salmon, marine mammals and many birds.
- Smelt spawn on gravel and sand beaches near the high tide line, where overhanging vegetation protects the eggs from the summer sun.
- Some stocks spawn during summer months, others in winter, others year-round.

http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare/Fact-Sheet-21-Forage-Fish.pdf

3. Activities

Places of Transition– Shoreline Ecotones

adapted from The Edge of Home, Project Wild, Canadian Wildlife Federation
(See extensions section for freshwater adaptations)

Age: grades 4 to 11

Time: Two one hour sessions

Group Size – any

Setting – Indoors and outdoors

Materials
Hula hoops – two for each pair of students.
Pencil crayons
Paper and pencils, clipboards
World map

Objective – Students will be able to identify what an ecotone is, and the characteristics of overlapping ecosystems (ecotones) at their local shorelines and other areas. They will also be able to define the nearshore, and provide evidence of the transitions from backshore to foreshore to subtidal zones.

Curriculum links:
Grade 4 Science - All living things sense and respond to their environment.
Energy can be transformed.
Grade 5 Science – Multicellular organisms have organ systems that enable them to survive and interact within their environment.
Experience and interpret the local environment
Grade 7 Science
The theory of evolution by natural selection provides an explanation for the diversity and survival of living things.
Communication
English Language Arts
Grade 8 Science
Questioning and predicting
Grade 9 Science
Matter cycles within biotic and abiotic components of ecosystems
Questioning and predicting
Grade 10 Science (new curriculum)
Energy is conserved and its transformation can affect living things and the environment.
Grade 11 Environmental Science (new curriculum)
Diversity, Sustainability, Processes and Changes in Local Ecosystems
Conservation and Restoration of Ecosystems

Life Science
Characteristics of Living Things
Process of Evolution

Overview
Students learn the concept of these places of transition by creating a visual model, then explore the reality of ecotones by visiting places where habitats overlap. (ie, seashore, parking lot edge at school, or wetland/forest)
In part 1, after class discussion of terms and definitions, using hula hoops, students will create an ecotone and gain understanding of what an ecotone is.
In part 2, the class will visit a marine shoreline ecotone or other area.

Background (also see **Supplementary Information**)
Ecotones are places of change. This is where there is a transition between two different ecosystems. Where ecosystems (also called biomes) come together and overlap are the places of species diversity. This area of overlap is called an ecotone. Ecotones are rich with species because plants and animals from both ecosystems are found there, along with those adapted specifically to the ecotone environment. The ecotone that will be in focus is the marine nearshore zone, where the land meets the sea.

What is the marine nearshore? – The nearshore is an ecotone.
Where the land meets the sea is a prime example of two ecosystems overlapping. The nearshore is a general term for the shoreline area that encompasses the foreshore (intertidal from the highest high tide to the lowest low tide) and subtidal zones (below low tide zone to a depth of 10 meters). The backshore area has also been included, as the impacts on the foreshore from activities in the backshore area are significant. (see Glossary)

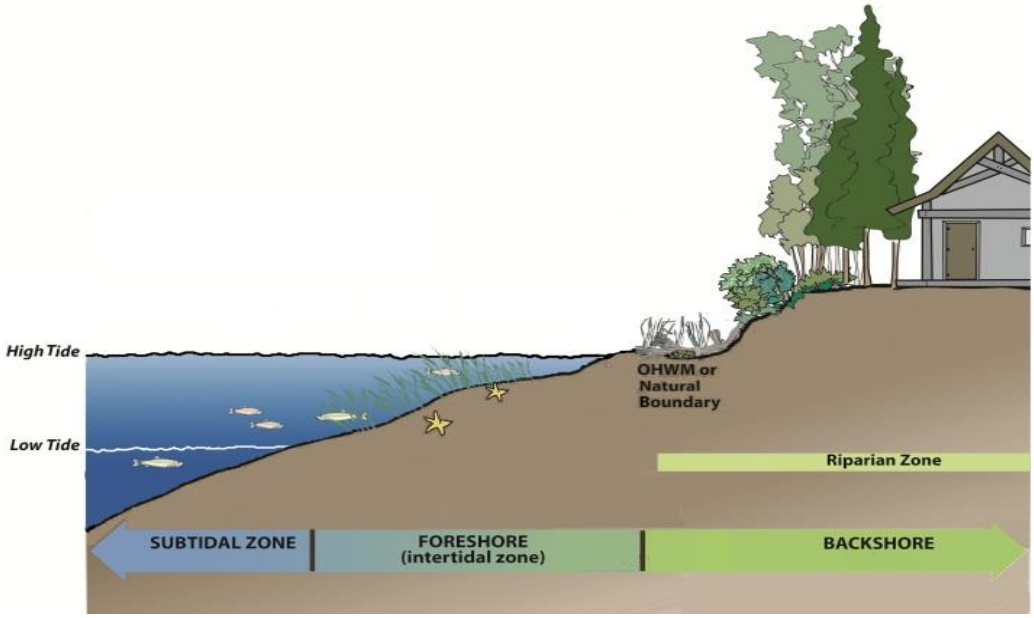


Figure 1: Parts of the shore—marine example. Source: Green Shores BC

Impacts on the marine nearshore

The shoreline ecotone is an area of great interest to humans. It is an exciting and beautiful area, an edge, where the powerful elements of weather and ocean are most evident. This area is highly valued as a location for homes, lodges, resorts, camps, marinas, parks, and recreation in many forms.

With the introduction of human dwelling comes the desire for an unobstructed view of the ocean, the defoliation of backshore slopes for building sites, access, and parking, and commercial ventures.

Why is this a problem? The pressure placed on the nearshore can be immense. Dredging for adequate water depths for marinas and marine structures can destroy eelgrass beds by disturbance or by shading.

Placing docks over eelgrass beds starves this photosynthesizing plant of sunlight, and over time will destroy the eelgrass within the shaded area. Fragmented eelgrass beds are weakened and vulnerable.

Building close to the water's edge for the best view creates the need for protection in the form of cement barriers or rock walls which change the character of the beach and destroy spawning habitat for forage fish.

When species begin to disappear or are diminished in numbers, this is evidence of damage. A large diversity of species is a sign of a healthy ecotone.

Glossary

Backshore – The upper zone of a beach (or land above the ordinary high water mark) beyond the reach of normal waves and tides, landward of the beach face. The backshore is subject to periodic flooding by storms and extreme tides, and is often the site of dunes and back-barrier wetlands (Figure 1).

Biome – Biomes are **large** regions of the world with similar plants, animals, and other living things that are adapted to the climate and other conditions. Biomes are defined as the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment. World biomes are freshwater, marine, tundra, desert, forest, and grassland**.**

Community – a group of organisms or a social group interacting in a specific region under similar environmental conditions.

Ecosystem –an ecosystem is an interacting community of organisms and their physical environments, with the essential function of the system to capture and distribute energy and to cycle nutrients. **An ecosystem can be large or small.**

Ecotone - the zone where two ecosystems or biomes overlap. Ecotones are areas where different habitats overlap, where the land and the ocean meet, for example, or a river and estuary intersect. Ecotones are rich with species because plants and animals from both ecosystems might be found there, along with those adapted specifically to the hybrid environment.

Intertidal – the area of shoreline between the highest high tide and the lowest low tide.

Nearshore – The nearshore zone encompasses the foreshore (intertidal from the highest high tide to the lowest low tide) and subtidal zones (below low tide zone) to

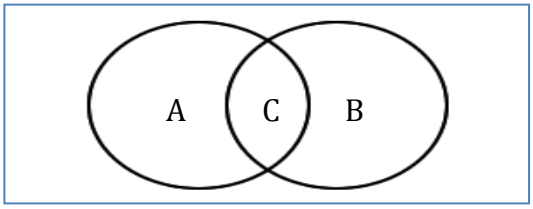
a depth of 10 meters. For the purposes of this lesson, the backshore area to a height of 60 meters above the ordinary high water mark (OHWM) is also included.
OHWM – Ordinary High Water Mark. The highest level reached by a body of water that has been maintained for a sufficient period of time to leave evidence on the landscape (Figure 1). Another term that is used for the same area is the Natural Boundary.
Subtidal- In marine systems, the area below low tide level but still relatively shallow and close to shore, typically to a depth of about 35 feet/10 m (Figure 1).
Transition – change from one thing or state to another.

http://greenshoresforhomes.org/resources/glossary/

Procedure

Part 1- Marine Ecotones – defining and building.
One hour.

1. Begin with the definition of an ecosystem, a biome, and an ecotone. (See glossary) To start, draw two circles that intersect on the board.
Explain that each circle is an ecosystem or biome, and where the two overlap is an ecotone. Then draw several shapes in one circle, and several different shapes in the other. In the centre, where the overlap occurs, draw several of the shapes from each of the outlying circles, plus one or two shapes that are unique to the overlap.
Discuss with the class the abundance and diversity of the objects in the ecotone, and using a map, discuss examples of biomes and ecotones in the world, then look at a local map of the marine/land interface and discuss the nearshore biome. (freshwater/land interface can also be used to discuss this biome)



At this point ask the students – in pairs - to draw their own overlapping ecosystems. Using coloured pencils, students draw two circles, and colour the overlapping area (ecotone) with both colours so that they will blend if they use pencil crayons , or have the students do varieties of creatures each ecosystem making sure the colours from each ecosystem circle are different and the overlap is left empty. Now ask them to provide a blend of the creatures from the two ecosystems in the overlap area, plus add creatures that are unique to the ecotone, using either shape, colour, or both.
The class will then have a discussion of what their ecosystems were, what plants, animals, or other organisms could live there, and what happens at the ecotone where the transition takes place.
Take students outside and divide group into pairs, giving each pair two hula hoops to represent two ecosystems, and clipboards and paper to record.

Explain that they are looking for places of transition – ecotones, on a small scale. Ask them to find an area where there is a transition and place the hoops so that the ecotone is where it would naturally occur, and instruct students to place hoops so that any unique species or features are evident.
Using clipboards, each team should take note of the variety of plants, animals, soils, or other organisms they see in each of the hoop areas (denote ecosystems A and B, and C the ecotone.

*Students do not need to identify and name all the different organisms, only whether plant, animal, soil, or other organism, and number of each different type.
Tell the pairs of students to be prepared to explain why they chose the particular area, and what evidence they found to prove this truly is an ecotone. (ie. number of plants, animals, organisms, which are found in the surrounding ecosystems and organisms unique to the transition or ecotone area)
Discuss the fact that these are "mini" ecosystems, and that large ecosystems or biomes can be huge tracts of land covering large portions of earth's continents.

Part 2 – Visiting a marine ecotone
(A visit to a fresh water ecotone can be substituted – see extension)
One hour.
Take students to the beach at low tide (choose a dropping tide for safety) and start by walking through the backshore area looking for the high water boundary. (where land plants end, where there are watermarks on rock faces, or other signs such as debris lines, plant material deposits). Discuss the various clues that indicate where the influence of the ocean ends.

Next go to the intertidal area (between the highest high and lowest low tides) and try to find some plants or animals from the backshore area. Then find unique plants or animals that do not exist in the backshore. Are there some plants that are salt tolerant? Discuss how these organisms have adapted to survive in this place of transition.
From there go to the ocean's edge and look at the subtidal area and discuss what is found just below the ocean surface in the shallow waters where light penetrates. Look to see if there are organisms that are exposed due to the low tide that would be normally under the water.

Give each pair of students a clip board with paper. Instruct students to do observations and lists of plants, animals, and other organisms starting at the transition area between the land and ocean effect, then within the intertidal zone, then at the water's edge. A hula hoop can be used to define a specific spot in each of the zones.

Extensions

Visit a fresh water ecotone. Go to a lakeshore or river edge and observe the transitions and note changes in plants, animals, and other organisms.
Discuss what we can do to minimize the impacts on nearshore from human activities such as building, clearing, recreation, etc.

- mimic natural systems,
- use plants to hold soils in place,
- retain logs at highest tide line to soften impact from waves,
- preserve overhanging vegetation and trees to provide shade for shoreline spawning fishes
- protect eelgrass as it helps to hold substrate in place just offshore and mitigate wave intensity.

Evaluation

Ask students to define ecosystems and ecotones.
Ask students to point out what characteristics to look for in an ecotone.
Discuss why ecotones are desirable places for humans – what draws people to these areas and why can this create problems?
Name some backshore activities that could affect the intertidal and subtidal areas of the nearshore.
How do these backshore activities affect the intertidal and subtidal areas of the nearshore?

Resources and references

www.greenshores.ca
Credits Ratings Guide - Stewardship Centre for BC

http://canadianbiodiversity.mcgill.ca/english/ecozones/pacificmarine/pacificmarine.htm
Ecotones – The Transitional Zones - Author: Medha Hegde
http://www.biotecharticles.com/Biology-Article/Ecotones-The-Transitional-Zones-2191.html

Heerhartz, S.M., Dethier, M.N., Toft, J.D. et al. Estuaries and Coasts (2014) 37: 1256. doi:10.1007/s12237-013-9754-5
http://link.springer.com/article/10.1007%2Fs12237-013-9754-5

Project Wild, Canadian Wildlife Federation.
http://cwf-fcf.org/en/explore-our-work/education/for-educators/project-wild.html

Life at the Nearshore – A Survival and Habitats Game.

created by Dianne Sanford

Age - Intermediate level +

Time – approximately 1 hour including discussion.

Group Size - 15 or more students, can accommodate large groups.

Setting – Gym or large playing field

Materials

Picture cards of forage fish, sea creatures, and predators. (9 each of herring and sand lance, 3 salmon cards, 2 shore crabs and 2 barnacles, one of orca, fish boat, and seal.)
Adjust according to class size, reducing fish if necessary, keeping all predators.
Ropes or pylons to mark off area.
Shorter length of rope (or several overlapping hula hoops) to represent an eelgrass bed offshore.
Background information on eelgrass, forage fish, and nearshore.

Objective: To reach the best habitat for your survival according to your needs, and to know why this is the best habitat for you and who your predators are.

Curriculum links:
Grade 4 Science - All living things sense and respond to their environment.
Energy can be transformed**.**
Communicating
Grade 5 Science – Multicellular organisms have organ systems that enable them to survive and interact within their environment.
Experience and interpret the local environment
Grade 6 Science
Multicellular organisms rely on internal systems to survive, reproduce, and interact with their environment.
Questioning and predicting
English Language Arts
Comprehend and connect (reading, listening, viewing)
Grade 7 Science
The theory of evolution by natural selection provides an explanation for the diversity and survival of living things.
Communication, English Language Arts
Grade 8 Science
Questioning and predicting
Grade 9 Science
Matter cycles within biotic and abiotic components of ecosystems
Questioning and predicting
Grade 10 Science
Energy is conserved and its transformation can affect living things and the environment**Grade 11 Environmental Science (new curriculum)**

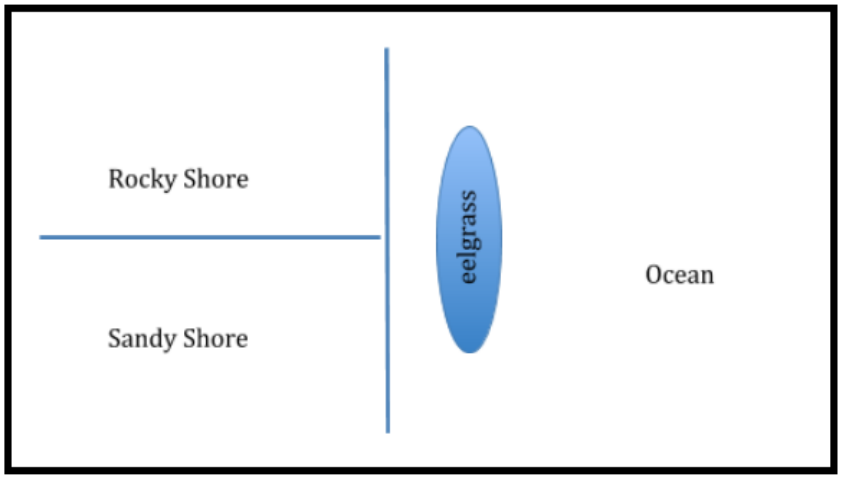
Diversity, Sustainability, Processes and Changes in Local Ecosystems
Conservation and Restoration of Ecosystems
Life Science
Characteristics of Living Things , Process of Evolution

Overview:
Starting at the end of the ocean, students need to make it to their best habitats (for survival and/or spawning) without being caught by a predator, and be prepared to explain why they chose where they are. The predators need to justify what they caught – is it their natural prey?

Procedure-

Game area set-up

A large enough area for entire class, (gym or playing field). Set up a rectangular area with over one half as ocean, other piece divided in two, horizontally, to become two different beach habitats, one sandy beach, one rocky beach. The shorter rope is used offshore to create a shape to represent an eelgrass bed.



^ start

Hand out cards to students, have them look at the facts on the card. Explain areas that are set out, and that their goal is to make it to their "preferred" habitats without being tagged by a predator. Respond to any questions from students about their creatures before the game starts.

The forage fish in this activity - herring and sand lance, travel as groups, and are looking for their appropriate spawning areas. There are many types of forage fish, but for this game we will use herring and sand lance.

Predators that eat forage fish are only allowed to tag one forage fish at a time.

Shore crabs and barnacles are looking for suitable habitat to live. They are in process of transforming from the zooplankton (free floating) ocean phase to adult life.

Students choose areas to inhabit or spawn according to the needs of their particular creature. There is a choice of **cobble or sandy beach, or eelgrass bed**. They are safe if they get to these areas untagged by predators. Predators must stay within the ocean area, and cannot reach into the eelgrass area to catch prey once the prey have made it to safety.

Discuss the predators, assign predator cards to students, and tell the predators they have to stay within the ocean area.

Each "prey" then decides which habitat type would be best for them. The herring and sand lance schools can decide amongst the group.
If tagged by a predator, as they try to make their way to suitable habitat, they die and have to go off play area to the side boundaries.

Predators and prey must have their cards visible at all times so they can decide if they would be prey for the predator or vice versa.

Keep the card with you, as there will be discussion of survival tactics of the different species at the end of the game, and you will be asked why you chose the habitat you are at.

Game ends when all participants have either died or settled in their preferred habitats or spawning areas.

Discussion questions

Prey (herring, sand lance, barnacles, shore crabs – are there any others?)

1. Why did you pick the habitat you are at?
2. What adaptations do you have to survive or spawn there?
3. Could you survive in the other habitats? Would there be seasonal variations in your habitat?
4. Could you be a predator to some of the creatures heading to a habitat? Which ones?
5. If you died, what happened? Do you think many of your species would succumb to this predator or this problem?

Predators (can any of these be prey?)

1. Was it easy or difficult to catch schooling prey?
2. Was it difficult to determine who your prey was at times?
3. Could there be situations where you might be prey to some of the other predators?

Background
(also see **Supplementary Information** in **Parts of this Lesson Plan** for more detail on species**)**

What is the nearshore? – This is a general term for the shoreline area that encompasses the foreshore (intertidal from the highest high tide to the lowest low tide) and subtidal zones (below low tide zone) to a depth of 10 meters.
The backshore area to a height of 60 meters above the ordinary high water mark (OHWM) has also been included in this activity, as the impacts from human activities in the backshore area and all of the nearshore are significant.

Impacts on the nearshore
The shoreline ecotone is an area of great interest to humans. It is an exciting and beautiful area, an edge, where the powerful elements of weather and ocean are most evident. This area is highly valued as a location for homes, lodges, resorts, camps, marinas, parks, and recreation of many forms.
With the introduction of human dwelling comes the desire for an unobstructed view of the ocean, the defoliation of backshore slopes for building sites, access and parking, and commercial ventures.
Why is this a problem? The pressure placed on the nearshore can be immense. Dredging for adequate water depths for marinas can destroy **eelgrass beds.** Structures over the water can shade eelgrass and over time kill portions of the beds. Building close to the water's edge for the best view creates the need for protection from storms in the form of cement barriers or rock walls, which change the character of the beach and can destroy spawning habitats.

The nearshore area is utilized by many organisms.

Forage fish are schooling, small fish, including herring, smelt, sand lance, anchovy, eulachon and more. (sand lance and herring cards are used in this activity). Schooling fish travel together for protection from predators, "safety in numbers", as well as to help in foraging for food. Many eyes looking for food is much more efficient than solitary fish. Forage fish, in turn, are food for many other larger fish, birds, and mammals, such as salmon, orca whales, seals, gulls, diving ducks, and humans.

Sand lance lay their eggs in the intertidal zone in the sand. The eggs are able to survive in the damp sand until they hatch and head to sea. **Herring l**ay their eggs on eelgrass and marine algae offshore, with the eggs remaining attached until they hatch. **Barnacles and shore crab** (as well as many other shore species) start out life as zooplankton, free floating in the ocean. As they grow, they "settle" to areas in the intertidal zone to feed, grow, and reproduce.

Eelgrass is a true plant (using photosynthesis from sunlight to create food, producing seeds and pollen to reproduce, and having roots, not the "holdfast" that other marine plants have).
Eelgrass is important for stabilizing the sea bottom near the shoreline, producing oxygen, and sequestering sediments, as well as providing a place of shelter and food

for many marine organisms. Eelgrass is a nursery for many ocean creatures, including larval sand lance and surf smelt, and provides a place for herring to deposit their spawn. Salmon smolts stop here on their journey to the ocean from the rivers of their birth.

Glossary of **Terms**

Biome – Biomes are large regions of the world with similar plants, animals, and other living things that are adapted to the climate and other conditions. Biomes are defined as the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment. World biomes are freshwater, marine, tundra, desert, forest, and grassland**.**

Community – a group of organisms or a social group interacting in a specific region under similar environmental conditions.

Ecosystem

- **the system of interactions between living and non-living things.**
- An ecosystem is an interacting community of organisms and their physical environments, with the essential function of such a system to capture and distribute energy and to cycle nutrients.

Ecotone

- the zone where two ecosystems or biomes overlap. Ecotones are areas where different habitats overlap, where a prairie and forest meet, for example, or a river and estuary intersect. Ecotones are rich with species because plants and animals from both ecosystems might be found there, along with those adapted specifically to the hybrid environment.

Eelgrass - Eelgrass is a type of submerged aquatic vegetation that grows along shorelines below the low tide level, and in estuaries and shallow bays. Eelgrass is not a seaweed which is actually an algae - it is a perennial flowering plant that is often used by herring for spawning. It is a critical habitat used as a nursery for many species of sea life, a source of food, both from the eelgrass itself, and the organisms it harbours. It is a safe haven and migration corridor, and a source of oxygen, being that it is a true photosynthetic plant.

Forage Fish: Small oceanic fish which eat plankton and are in turn eaten by larger fish. These fish provide a link between lower and higher levels of the food chain. There are many species, but in this document the species focus is herring, surf smelt and sand lance.

Food Web: a series of interlocking and interdependent food chains

Food Chain: a series of organisms each dependent on the next as a source of food

Interactions - ecosystems are described in terms of interactions. Biological interactions are the effects that the organisms in a community have on one another. In the natural world no organism exists in absolute isolation, and so every organism

must interact with the environment and other organisms. An organism's interactions with its environment are vital to the survival of that organism and the functioning of the ecosystem as a whole.

Evaluation

1. Define what a forage fish is and provide details of the herring and sand lance spawning behaviour.
2. Name some other fish that you think may be “forage fish”.
2. Can you see how human activities could affect shorelines?
3. What does eelgrass provide for the marine community?
4. Name some shoreline organisms that start out life as zooplankton**.**

Extensions

Add cement or rock walls to the shorelines in the game aream (use pieces of wood, rope, etc.) and discuss the changes this would make to the beach before playing another round of the game.

Remove or reduce the size of the eelgrass bed, play the game and discuss the differences.

Add additional predators, add a resort or marina, or add more species to the game. Discuss the impacts of these changes.

Resources and Game Cards

CITY OF BELLINGHAM
Marine Nearshore Habitat Connectivity Study
https://www.cob.org/documents/pw/environment/restoration/nearshore-connectivity-study-final-report.pdf

Levings CD, Jamieson GS. Marine and estuarine riparian habitats and their role in coastal ecosystems, Pacific region. Canadian Science Advisory Secretariat; 2001. http://publications.gc.ca/collections/collection_2015/mpo-dfo/Fs70-5-2001-109-eng.pdf

Policy on New Fisheries for Forage Species - http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/forage-eng.htm

Resource for fresh water shoreline.

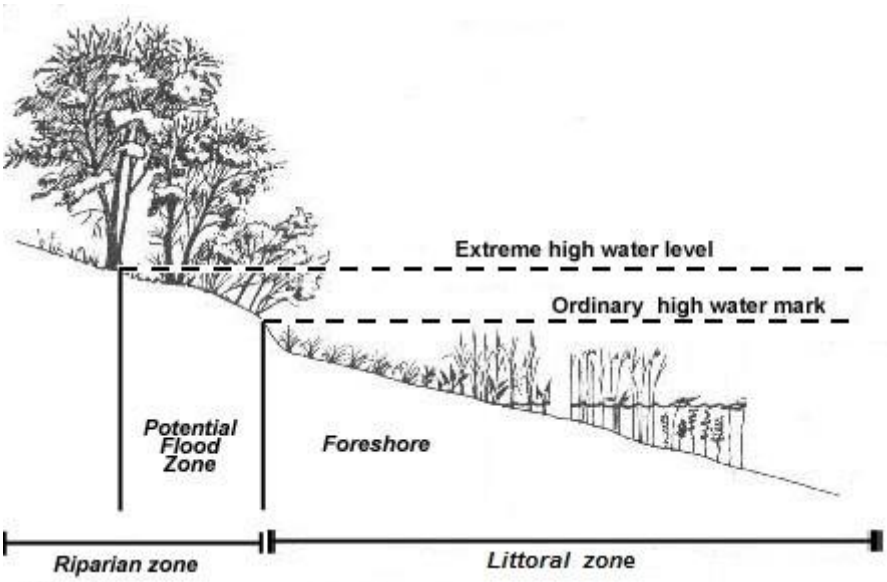


Figure 2: Parts of the shore—lake example
Courtesy of Fisheries and Oceans Canada

photo: Ramona De Graaf

Offshore eelgrass meadows

photo by Dianne Sanford

Eelgrass exposed during lowest tides.

Pacific herring photo by John Buchanan


Herring spawn on rockweed (Fucus spp.) photo by John Buchanan

photo: Ramona De Graaf

High intertidal zone – forage fish spawning area.

photo: Ramona De Graaf

Two shore spawning forage fishes.
Upper fish – Surf Smelt Lower fish – Pacific Sand Lance

Barnacle

- A barnacle starts its life as a free floating zooplankton in the ocean.

-Barnacles are prey for many animals including fish and crabs during their larval phase as they have little protection. Once they have settled on rocks and other hard surfaces, they produce an outer shell and are protected

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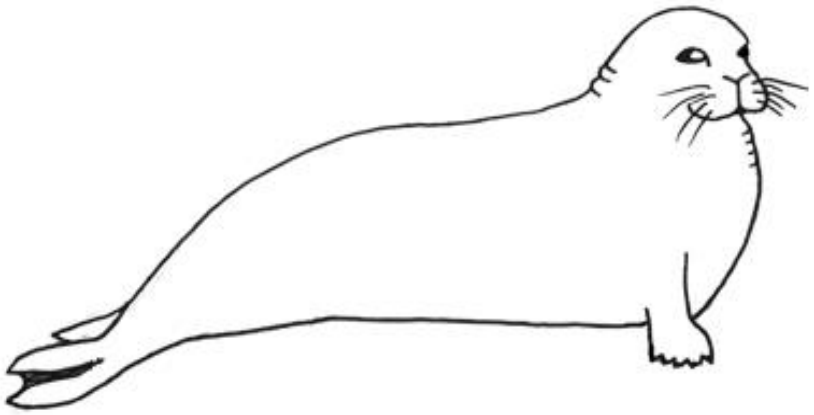
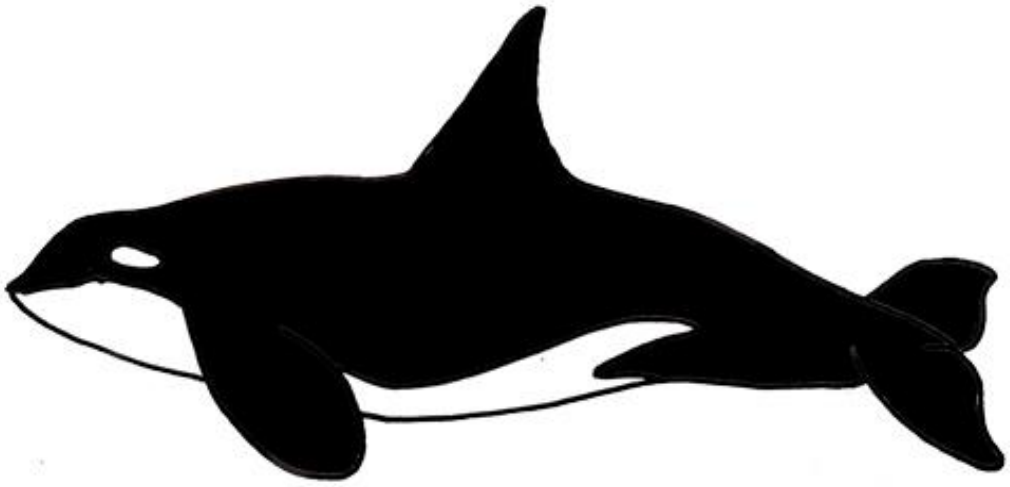


Seal

-Seals eat forage fish, salmon, and crabs and clams.

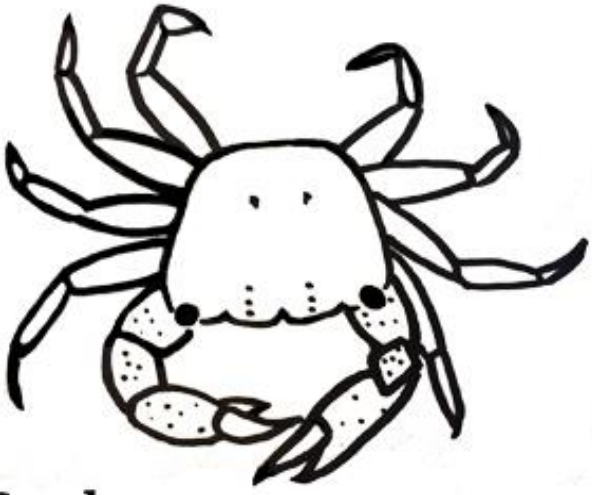
-Seals are prey for sharks, Orca whales and humans.



Orca

- Orca eat salmon, some eat seals.

- Orca live in close family groups made up of males, females, and young.



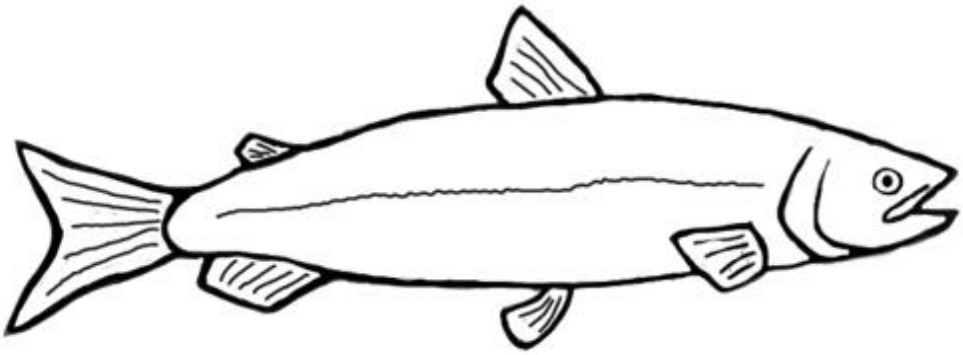
Shore Crab

- Shore crabs start out life as part of the free-floating zooplankton in the ocean, and settle down to life on the shoreline as they transition to their adult form.

- As adults, shore crabs molt their shell in order to grow– this happens more than once a year depending on conditions in their environment.

Humans

- Humans prey upon seals, herring, crab, and salmon.
- Humans are the most efficient predator of salmon and herring.
- Humans impact nearshore areas.



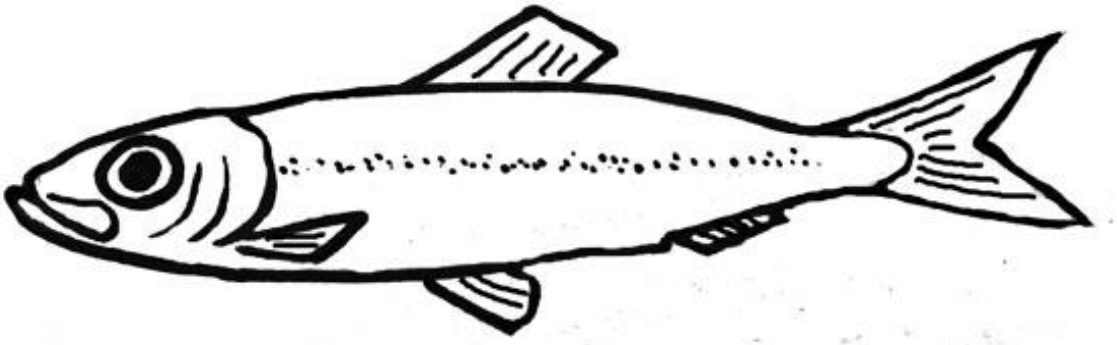
Salmon

- Salmon return to the same stream that they were born in to spawn and then die.
- Salmon prey on forage fish.
- Salmon are prey for seals, orca, and humans.

Sandlance

-This forage fish lives near the shore year-round and spawns on sand or pebbled beaches in the intertidal zone during the winter.

-There is no commercial fishery for sand lance.



Herring

- Fish, sea mammals, and birds rely on this forage fish and its eggs for food.
- There is a commercial fishery for herring.
- During spawning, herring attach their eggs to marine algae, eelgrass, and even pilings.