Lesson 3: Great Bear Sea Case Studies

Overview: In small groups, students will explore case studies of current activities and research going on in the Great Bear Sea region. Students report out the case study findings to their peers using a jigsaw strategy.

Suggested Time: 2 classes (75 minutes each)

* **Teacher Note:** Materials with a * are available on the Great Bear Sea USB, or at www.greatbearsea.net.

Materials and Resources:

- Personal viewing devices (tablets, computer lab access, etc.)
- Teacher Background – Lesson 3
- Great Bear Sea Case Studies
  - ¤ Case Study 1: Kelp Forest
    - Otter Kelp Research (8 mins)
    - Case Study 1: Kelp Harvest Data
    - Kelp Research Images *
  - ¤ Case Study 2: Bears
    - Bear Research (5 mins)
    - Case Study 2: Bear Data
    - Bear Images *
    - Bear Identification *
  - ¤ Case Study 3: Pacific Herring
    - Herring Research (21 mins)
    - Case Study 3: Pacific Herring Research
  - ¤ Case Study 4: Cumulative Effects – North Coast
    - Cumulative Effects (20 mins)
    - Eelgrass (8 mins)
    - Case Study 4: Cumulative Effects – North Coast
  - ¤ Case Study 5: Clam Gardens
    - Clam Gardens (2 mins)
    - Case Study 5: Clam Gardens
    - Kwakwaka'wakw Seasonal Use Cycle *
- 3.1 Great Bear Sea Case Studies
- 3.2 Self-Assessment Checklist
- 3.3 Group Assessment Checklist

Learning Objectives:

Students will:

1. Explore and identify local place-based examples of research, resource management and resource planning.
2. Explore different examples of collaborative research and identify use of different knowledges in marine-planning.
3. Interpret the local environment through analyzing information and data.
4. Use scientific and inquiry processing skills to analyze information, critique environmental questions, and draw conclusions.
5. Develop processes for working together and communicating findings with others.

Lesson Context

Part A of this lesson introduces students to some of the collaborative science that is taking place in various areas of the Great Bear Sea region. In small groups, students will work with a particular case study (combination of film clips, background information and research data) showcasing scenarios that are currently underway in the Great Bear Sea. In their groups, students will provide a synopsis of the case study and answer some guiding questions. **Part B** has students forming new groups and sharing their learning with others. Using a jigsaw approach, students get exposure to multiple examples of collaborative research methodologies focusing on sustainable resource management and marine planning.

This structure assumes that student groups have access to technology to view the film portion of their case studies as a small group (on devices in the classroom or in a computer lab). Depending on your circumstances, students could watch the film clips at home or the class could watch all the film clips together and then break off into groups thereafter to explore the additional materials and plan their presentations. For watching at home, the clips are available on the website: www.greatbearsea.net. Clips on the website are Youtube links, so these can be embedded into your own class website and/or online learning space, with additional instructions for students, opportunities for sharing comments between students and groups, etc.

The **Teacher Background – Lesson 3** provides an overview of the 5 case studies.

Learning Activities

Part A (1 class session + individual viewing time, where needed)

Activity 1: Exploring Great Bear Sea Case Studies (75 minutes)

1. Review some key aspects of "collaborative research."
2. Divide the class into 5 groups and provide each student with a copy of **3.1 Great Bear Sea Resource Management Case Studies** and review as a class.
3. Provide each group with one of the case studies and explain that as a group they should work through the questions, but each student should prepare a written version of **3.1 Great Bear Sea Resource Management Case Studies** in order to share their learning with other students the following day.
4. The **Teacher Background – Lesson 3** includes answers to the data research questions for Case Studies 1 and 2.
5. Ensure students have completed their own version of **3.1 Great Bear Sea Resource**

Management Case Studies in preparation for the next class.

6. Provide each student with a copy of **3.2 Self-Assessment Checklist** and each group with a copy of **3.3 Group Assessment Checklist** and have students/groups complete them now or later in the lesson.

Part B

Activity 1: Sharing Great Bear Sea Case Studies (60 - 75 minutes)

1. Using a jigsaw pattern, have students form new groups so that there are representatives from each of the 5 case study groups. Have each student (or multiple students) from the particular case study groups share their learning with others, using their completed **3.1 Great Bear Sea Resource Management Case Studies** as a guide.
2. Student groups may wish to keep an eye on the presentation time for each case study representative(s) to allow for ample time for all to share.
3. Those listening should prepare 1 question and 1 comment for the presenter to address after they share. You may wish to structure this in a different way to ensure active, respectful listening and engagement by all group members.

Activity 2: Class Discussion – Collaborative Research in the Great Bear Sea (20 minutes)

1. Facilitate a class discussion to address any questions that arose in small groups that may not have been answered. Have others contribute to responses.
2. Have students note 2 - 3 questions about an area of interest after hearing about all of the case studies.
3. Have each case study group make a recommendation for further research about the featured resource in their particular case study. You may wish to collect these as exit slips at the end of the class.

Extension Ideas

- Use student questions and areas of interest to fuel personal inquiry studies at the end of this unit.
- Provide students with access to watch the other case study clips based on personal interests. The film clips can be accessed through the website at www.greatbearsea.net; as the clips are accessible via YouTube, you may also wish to embed them on your own website, along with discussion questions, etc.

Assessment Ideas

- Formatively assess students' engagement in group work and large group discussion. You may wish to develop a class rubric for active and respectful listening.
- Collect **3.1 Great Bear Sea Resource Management Case Studies** and **3.2 Self-Assessment Checklist** for each student, and **3.3 Group Assessment Checklist** for each group.

Teacher Background – Lesson 3

There are 5 case studies presented in this lesson, each looking at different species and/or approaches to resource management and planning in the Great Bear Sea. The case studies have been prepared so that students can review the materials for information and summarize the findings using **3.1 Great Bear Sea Resource Management Case Studies**. Some case studies also include data and research questions so that groups can analyze the data and attempt to answer the questions.

Brief summaries of each case study are provided below. It is also recommended that you review the case study materials and film clips.

Case Study 1: Kelp Forests

This case study includes a film clip about kelp forests, as well as background information and research data from Kira Krumhansl, Postdoctoral Researcher at Simon Fraser University and Hakai Institute. The film clip explores the delicate relationship between kelp and sea urchins, with urchins having the capability to control the diversity, distribution and productivity of entire kelp forest ecosystems. Any force acting on these kelp forests can tip the balance of this delicate ecosystem. The research data looks specifically at the impacts of harvesting kelp.

This research data includes some questions for students to analyze. Questions and answers are provided here:

> **Question One:** Did kelps grow back at the same rate at each site? Find the average growth rate at each site. What is the range of the average kelp growth rate for each site?
>
> **Answer:** No, kelps grew back at different rates across sites. The average growth rates are: Golden 0.053; Meay 0.53; Simonds 0.62; Strykeer 0.045; Triquet 0.009 m per day (i.e. surface canopy growth per day). The range of growth rates was 0.009 (Triquet)-0.062 (Simonds) m per day.
>
> **Question Two:** Is the water temperature the same at each site? What is the range of average water temperatures? What is the average water temperature?
>
> **Answer:** No, the average water temperature varied among the fives sites. The average temperatures ranged from 11.96 (Simonds)-12.70 (Triquet)°C. The average temperature among the five sites was 12.32°C.
>
> **Question Three:** Is the kelp density the same at each site? What is the average kelp density?
>
> **Answer:** No, the average kelp density ranged from 0.15 (Meay)-0.49 (Triquet) kelps m^{-2} (i.e. how many kelps there are per meter of ocean bottom). The average kelp density (rounding to the nearest ten thousandths) among the five sites was 0.4005 m^{-2} (per meter of ocean bottom).

Question Four: Does the water temperature influence how quickly kelps regrow?

Answer: Yes, kelp re-growth rate decreased at higher average water temperature.

Question Five: Which factor out of those you considered do you think was most important in determining kelp recovery rates? What implications does this have for harvest?

Answer: Temperature was the most important variable determining kelp regrowth rates. Climate change is expected to cause increases in water temperature, which may impact the ability of kelps to recover from harvest in the future. Harvest managers should consider monitoring water temperatures in association with harvest so that they can reduce or avoid harvesting during years with warm water.

NOTE: Permission was granted to use the data in the context of this lesson. The data are not available for publication or use outside of the classroom.

Case Study 2: Bears

This case study includes a film clip from *Bear Witness*, as well as background information and data supplied by researchers with the Spirit Bear Research Foundation. The Spirit Bear Research Foundation is a collaboration between the Kitasoo/Xai'xais First Nation and conservation scientists conducting locally relevant, ecosystem-based wildlife research to address pressing conservation concerns in BC's Great Bear Rainforest.

The research data includes questions for students to analyze about the monitoring and movement of bears using non-invasive methods to see which bears are around, how they are moving across the territory and how much salmon they have been eating.

Questions and answers are provided here:

Question 1: What do you notice about the diet of these bears? What species eats the most salmon? What bear eats the least salmon?

Answer 1: There is individual variation. Least is a female black bear that eats 3% salmon. Most is a male grizzly that eats 88% salmon.

Question 2: Which species eats more salmon? Calculate the averages, for example, on average how much salmon to grizzly bears eat vs black bears. Why?

Answer 2: Grizzly bears (average 72) eat more salmon than black bears (average 23).

Question 3: Does the gender of the bear make a difference to salmon consumption? Why or why not?

Answer 3: Males eat more salmon (52 average) than females (35 average). Also, the group can talk about the difference between proportion and amount. Why do you think males eat more salmon?

NOTE: Permission was granted to use the data in the context of this lesson. The data are not available for publication or use outside of the classroom.

Case Study 3: Pacific Herring

This case study includes a film clip and background information about collaborative research looking at the Pacific herring from the Herring Research Team in Klemtu, BC. The research is a partnership between the Central Coast Indigenous Resource Alliance, Simon Fraser University, and the people living in this region.

The Pacific herring is an extremely important species in the ecosystem. It is a food source for a wide variety of other species in the ecosystem, including whales and salmon, as well as land-based species like wolves and bears that come to the shoreline to feed when herring are spawning. It also is very important from a cultural perspective for many First Nations.

Changes in herring spawning behaviours and populations is a very important issue for First Nations communities. If herring change spawning behaviour this can have drastic consequences on the ecology of the area and the livelihood of those in the region.

Case Study 4: Cumulative Effects – North Coast

This case study includes two film clips and background information highlighting a groundbreaking new approach to how to look at the impacts of development in a region. This approach is being used on the North Coast, specifically in the region of the Skeena River and estuary, and it looks at the "cumulative effects" of ongoing development in the region. This means that rather than looking at one project at a time, the proposed development projects are being looked at together to see what cumulative effects the projects may have on both ecosystem and the people who live in the region. Some of these projects include forestry, fisheries, pipelines to feed liquefied natural gas (LNG) plants, LNG refineries and wind power mega-projects. Cumulative effects are basically the combined effects of past, present and future activities on a region and the things that people care about for ongoing sustenance and survival in a region.

The Cumulative Effects Monitoring Initiative is led by Environment Canada and Climate Change, and includes input from various stakeholders, including the First Nations along this coast: Gitga'at First Nation, Gitxaała First Nation, Haisla First Nation, Kitselas First Nation, Kitsumkalum First Nation, Metlakatla First Nation.

The first film clip provides an overview of multiple cumulative effects initiatives underway in the region, including the Cumulative Effects Monitoring Initiative, while the second clip looks specifically at eelgrass ecosystems. The clips provide information for students to analyze.

Case Study 5: Clam Gardens

This case study includes a film clip provided by Dr. Anne Salomon, and shared with permission here. The film clip details some of the research occurring on North Vancouver Island just off the coast of Quadra Island, in the Great Bear Sea. This research is led by Dr. Salomon at Simon Fraser University.

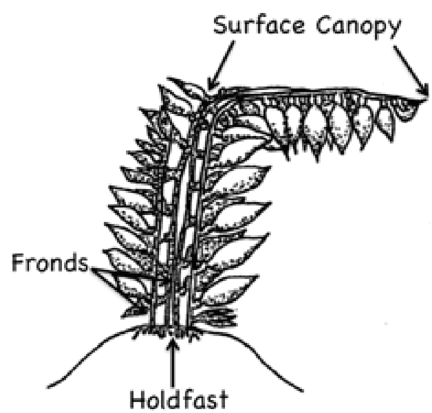
The case study also provides Traditional Ecologicial Knowledge, provided by the Member Nations of the Nanwakolas Council (North Vancouver Island) through an excerpt from the Ha-ma-yas Marine Plan, about the Nations in this region and the significance of the clam gardens. Clams were and are a vital food source of many First Nations in BC. Clam gardens are prehistoric rock walls that were made thousands of years ago. Elders share that rocks were rolled down to the shoreline at low tide and placed to form walls in the hopes of increasing the productivity of clams.

Case Study 1: Kelp Harvest Data

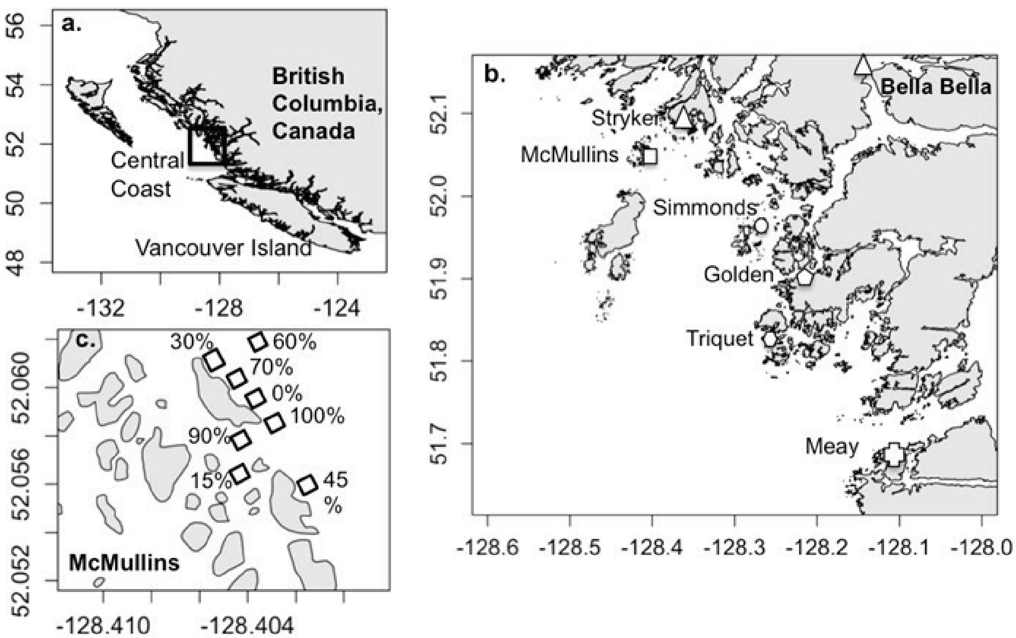
This information and data was submitted by Kira Krumhansl, Postdoctoral Researcher at Simon Fraser University and Hakai Institute. In collaboration with the Heiltsuk First Nation, researchers at Hakai Institute and Simon Fraser University conducted a kelp research project, looking closely at kelp harvesting, to see if kelp can be taken from the ecosystems without having a negative impact on other species in the ecosystem or on the carbon storage abilities of the kelp.

Background: Giant kelp (Macrocystis pyrifera) is the fastest growing primary producer on the planet. This species has been harvested by First Nations on the coast of British Columbia for millennia, and is still being used to collect herring eggs in the spring for subsistence and commercial fisheries (i.e. spawn on kelp fishery). Giant kelp is also being considered for other commercial uses, such as the production of fertilizers, food additives, and cosmetics. Before commercial harvests begin for these purposes, the Heiltsuk First Nation worked in collaboration with researchers at the Hakai Institute and Simon Fraser University to investigate how quickly the kelp recovers from harvest, and what factors influence how quickly kelp recovers. This information helps Heiltsuk Research Managers to determine whether commercial kelp harvesting is a sustainable activity, and if so, how best to manage it.

The basic anatomy of giant kelp is shown in the diagram below. Giant kelps are anchored to the substrate via a root-like structure known as a **holdfast**. Each holdfast has multiple stems or **frond** that grow up through the water column towards the surface of the water. Once the frond reaches the surface, it grows along the surface to form a **surface canopy**. This surface canopy is where most of the kelp's photosynthesis occurs, and is visible from a boat (maybe you've seen one!). Harvesting involves cutting the surface canopy portion of the kelp.



We harvested kelps at 5 sites on the Central Coast of BC near Bella Bella in 2014, where plots that measure 30 by 30 meters were set up as the study area (see the site maps below). We harvested kelp (involves cutting the surface canopy portion of the kelp) and measured how quickly the kelp regrew (meters of canopy growth per day). We were interested in understanding what factors influence how quickly the kelps regrow following harvest such as water temperature and the density of the kelp.



Some of the questions we were interested in were:

Would larger kelp individuals regrow more quickly (compared to smaller kelps)? Would kelps grow back more quickly when they are in sparse kelp beds or dense kelp beds? Does the water temperature influence how quickly kelps regrow?

To answer these questions, we measured the water temperature at each site (°C), the initial size of each harvested kelp before harvest (surface canopy length in meters), and the density of kelps at each site (kelps m^{-2}, i.e. how many kelps there are per meter of ocean bottom). We did an analysis of the data to investigate which factor was most important. What can you see in the data provided? Try to answer these questions for yourself:

Question 1: Did kelps grow back at the same rate at each site? Find the average growth rate at each site. What is the range of average growth rate for each site?

Question 2: Is the water temperature the same at each site? What is the range of average water temperatures? What is the average water temperature at each site?

Question 3: Is the kelp density the same at each site? What is the average kelp density?

Question 4: Does the water temperature influence how quickly kelps regrow?

Question 5: Which factor out of those you considered do you think was most important in determining kelp recovery rates? What implications does this have for harvest?

Table: Kelp Harvest Data

Site	Average Water Temperature (^0C)	Kelp Density at Site (m^{-2})	Initial Kelp Size (m)	Kelp Growth Rate (m per day)
Golden	12.4	0.336111111	10.9	0.066666667
Golden	12.4	0.336111111	6.4	0.050520833
Golden	12.4	0.336111111	10.9	0.067708333
Golden	12.4	0.336111111	6.4	0.028125
Golden	12.4	0.336111111	3.8	0.049479167
Meay	12.12	0.147222222	9	0.065306122
Meay	12.12	0.147222222	5.4	0.041836735
Meay	12.12	0.147222222	7	0.051020408
Simonds	11.96	0.233333333	7.6	0.067368421
Simonds	11.96	0.233333333	2.15	0.052631579
Simonds	11.96	0.233333333	4.4	0.043157895
Simonds	11.96	0.233333333	2.05	0.046315789
Simonds	11.96	0.233333333	7.3	0.101052632
Stryker	12.425	0.463888889	4.85	0.012121212
Stryker	12.425	0.463888889	7	0.046969697
Stryker	12.425	0.463888889	3	0.055050505
Stryker	12.425	0.463888889	2.8	0.074242424
Stryker	12.425	0.463888889	2.5	0.034343434
Triquet	12.702	0.486111111	4	0.007368421
Triquet	12.702	0.486111111	4.7	0.004210526
Triquet	12.702	0.486111111	6.05	0.011578947
Triquet	12.702	0.486111111	5.95	0.013684211

NOTE: Permission was granted to use the data in the context of this lesson. The data are not available for publication or use outside of the classroom.

Case Study 2: Bear Data

This information and data was submitted by Rosie Child – Field Technician, University of Victoria and Spirit Bear Research Foundation. See more information at www.spiritbearfoundation.com. Spirit Bear Research Foundation is a collaboration between the Kitasoo/Xai'xais First Nation and conservation scientists conducting locally relevant, ecosystem-based wildlife research to address pressing conservation concerns in British Columbia's Great Bear Rainforest.

We monitor bear populations and movement using non-invasive methods to see which bears are around, how they are moving across the territory and how much salmon they have been eating. We monitor the bears through remote cameras that show us when bears are around and how they are moving through the territory. We collect hair samples by using either a snag station (a corral built out of barbed wire) or use a rub tree (an existing rub tree that we wrap with barbed wire). The spring is the best time to collect samples as the bears are just waking up and are shedding hair from last fall. We track the bear movement and we use stable isotope analysis to tell us the proportion of the bear's diet that is salmon, marine mammal or plant based.

When identifying bears from the remote camera footage, it is best to use multiple characteristics such as colour, size, shoulder hump, face shape, and ear size. People often assume that black bears are black and that grizzly bears are brown. Grizzly bears are usually brown but can be very light to very dark in colouring. Black bears are usually black but can also be white, blue, cinnamon, or brown.

Colour

- Grizzly bears are usually brown and black bears are usually black, but there is lots of variation so colour is not the best way to identify bears.

Size

- Adult grizzly bears are usually larger than adult black bears but females and young bears are smaller and make size unreliable.

Shoulder Hump

- Grizzly bears have a prominent shoulder hump that is a mass of muscle that helps them dig.

Face Shape

- Black bears have a straight face profile, while grizzly bears have a more dished face profile.

Ear Size

- Black bears have taller ears in proportion to their head than grizzly bears shorter rounded ears.

Claws

- Grizzly bears have longer front claws that are usually lighter than black bear claws.

Table: Bear Data

The data below was collected during 2012, 2013, and 2015 during the spring and fall. What can you see in the data provided below? Try to answer these questions for yourself:

Question One: What do you notice about the diet of these bears? What species eats the most salmon? What bear eats the least salmon?

Question Two: Which species eats more salmon? Calculate the averages, for example, on average how much salmon do grizzly bears eat vs black bears. Why?

Question Three: Does the gender of the bear make a difference to salmon consumption? Why or why not?

Season	Year	Bear	Species	Sex	Salmon
spring	2014	25721	grizzly	female	0.634
spring	2014	23534	grizzly	female	0.594
spring	2014	14642	grizzly	female	0.617
Spring	2014	28132	grizzly	female	0.632
Spring	2014	10911	grizzly	female	0.637
Spring	2014	25852	grizzly	female	0.658
Spring	2014	10466	grizzly	female	0.671
Spring	2013	10680	grizzly	female	0.704
Spring	2013	10466	grizzly	female	0.705
Spring	2012	10911	grizzly	female	0.738
Spring	2014	23860	grizzly	female	0.746
Spring	2012	10667	grizzly	female	0.757
Spring	2012	10992	grizzly	male	0.827
Spring	2012	10567	grizzly	male	0.88
Spring	2012	10663	grizzly	male	0.636
Spring	2012	139903	grizzly	male	0.718
Spring	2012	10853	grizzly	male	0.736
Spring	2012	10981	grizzly	male	0.744
Spring	2012	10640	grizzly	male	0.744
Spring	2012	10303	grizzly	male	0.758
Spring	2012	10665	grizzly	male	0.809
Spring	2012	149691	grizzly	male	0.81
Spring	2012	10786	grizzly	male	0.812
Spring	2013	14256	black	female	0.035
Spring	2012	10936	black	female	0.037
Fall	2014	25723	black	female	0.052

Season	Year	Bear	Species	Sex	Salmon
Spring	2014	10646	black	female	0.07
Spring	2013	13723	black	female	0.071
Spring	2013	11706	black	female	0.074
Spring	2013	23452	black	female	0.084
Spring	2012	10646	black	female	0.103
Fall	2014	14837	black	female	0.254
Spring	2014	28476	black	female	0.449
Spring	2012	10635	black	female	0.032
Spring	2012	10602	black	female	0.036
Spring	2014	28080	black	female	0.039
Spring	2012	10585	black	female	0.046
Spring	2014	26964	black	female	0.167
Spring	2014	26396	black	female	0.172
Spring	2013	11497	black	female	0.309
Spring	2014	26999	black	female	0.471
Spring	2012	10598	black	male	0.195
Spring	2012	10320	black	male	0.225
Spring	2012	10592	black	male	0.342
Spring	2012	10820	black	male	0.344
Spring	2012	10429	black	male	0.406
Spring	2012	10622	black	male	0.422
Spring	2012	10607	black	male	0.043
Spring	2012	10603	black	male	0.079
Spring	2012	10714	black	male	0.266
Spring	2012	10484	black	male	0.351
Spring	2012	10533	black	male	0.517
Spring	2012	10526	black	male	0.586

NOTE: Permission was granted to use the data in the context of this lesson. The data are not available for publication or use outside of the classroom.

Case Study 3: Pacific Herring

This information was contributed by Kitasoo/Xai'xais First Nations, Alejandro Frid (Science Coordinator with the Central Coast Indigenous Resource Alliance) and several researchers from Simon Fraser University including Markus Thompson (Masters of Resource in Environmental Management) and Dan Okamoto (Postdoctoral Researcher) about the collaborative research happening in the Great Bear Sea region looking at the Pacific herring from the Herring Research Team in Klemtu, BC. The research is a partnership between the Central Coast Indigenous Resource Alliance, Simon Fraser University, and the people living in this region.

The Pacific herring is an extremely important species in the ecosystem. It is a food source for a wide variety of other species in the ecosystem, including whales and salmon, as well as land-based species like wolves and bears that come to the shoreline to feed when herring are spawning. It also has a very important from a cultural perspective for many First Nations on the coast.

Markus Thompson and his team are collaborating with Central Coast First Nations to look at recent changes in the behavior of herring. Pacific herring typically spawn in the shallow, the intertidal, where they can often be seen on the shoreline at low tide. But recently, spawn kelp fishers have been noticing that the herring have been spawning in deeper waters, at depths as deep as 30 or 40 meters below the surface, which is really uncharacteristic. It's not something that researchers or local fishers have seen before. There are a number of reasons and hypotheses around why this might be happening. And there are a number of consequences that could result in deeper spawning herring, so this is an important phenomenon and behaviour change to be researching given how important the Pacific herring are to the region and the whole ecosystem.

Some of the hypotheses about why the spawn is deeper include:

- The deeper spawning may be temperature induced due to increased temperatures with climate change or El Niño. The herring may be diving deeper to find colder water that they are more accustomed to.
- The deeper spawning may be an attempt to get away from predators that are in the area, or to move away from marine vessel traffic.

Some of the consequences of deeper spawning may include:

- In shallow waters there is a surface current to help with movement needed to fertilize the eggs. At deeper water levels, there is less current. Could that mean less eggs are being fertilized and thus less herring with be produced?
- Because not a lot is known about Pacific herring (how they move, behave, etc.), more has to be learned about the change in behaviour to understand how much can be safely harvested given the potential for less fertilization.

Collaborative research is very important in a situation like this, where local knowledge is very important to understanding behaviour change and the key places to collect data.

The First Nations in the region can share their observations from fishing the areas their entire lives, including the changes they have observed over time. Local fishermen lead the researchers to the key areas in the region where spawning is taking place, and particularly where the deep spawning is happening and when it is safe and productive to travel to these regions to collect data. For example, when the wind is blowing too hard, it would be impossible to collect reliable data.

As Markus Thompson describes in the film:

> *"Tomorrow we're going to head out into Kitasoo Bay, and we're going to set up an experiment to test how depth affects herring eggs. And to do this we're going to place eggs that we harvest from the natural spawn to three different depths in the bay. So we're going to put them at 30 meters, at 15 meters, and at 3 meters. To do this we going to have to have two dive crews out there. One dive crew is going to be harvesting while the other dive crew is collecting the stuff from harvesters and putting it into these pre-constructed frames, and those frames will be lowered from the surface to the bottom, and we will collect those eggs at different intervals. So, I collect them just before they hatch, and then I preserve them, bring them back to the lab and I can examine them with a microscope and see how well they survived, or if a lot of them have died. And we'll also have temperature, salinity and dissolved oxygen loggers on those systems."*

As Alejandro Frid describes in the film:

> *"What's rather exciting about all this work that I'm involved in is that it's not someone with an academic background like me coming into a place and bringing my own ideas, and just making my own moves, and making decisions as if I knew any better. It's about listening to people who have been living in place for many generations, have a very long-term perspective, who have an intimate relationship with their resources that nourished them culturally and as well economically, nutritionally, and saying: "Hey! We're noticing these changes. We understand a lot of this from our own perspective, but what can you as a scientist bring to round out our understanding better?" And that's a very enriching experience because it is the synergy of the old traditions and all of their wisdom. And new tools that science can contribute. It just complements our understanding as well. And it's very gratifying when requests for scientific research comes from the First Nations themselves."*

And as Clark Robinson Sr, Hereditary Chief, Kitasoo/Xai'xais Nation describes in the film:

> *"We need to make sure to respect the area, not to ruin it for the future. Make sure that we have enough going around there, for all of them. Not to overtake. Not to waste. Not to be disrespectful to any of the animals. They're all there to feed as well as we're going to feed ourselves. Make sure that we're looked after well with whatever we have left there for the herring."*

This research builds on First Nations Traditional Knowledge and the tools science can provide to better inform planning for years to come.

Case Study 4: Cumulative Effects – North Coast

The "cumulative effects" approach being used on the North Coast, specifically in the region of the Skeena River and estuary, is a groundbreaking new way of looking cumulatively at all of the impacts of development on a region. This means that rather than looking at one project at a time, the proposed development projects are being looked at together to see what cumulative (added all together) effects the projects may have on both ecosystem and the people who live in the region. Some of these projects include forestry, fisheries, pipelines to feed liquefied natural gas (LNG) plants, LNG refineries and wind power mega-projects. Cumulative effects are basically the combined effects of past, present and future activities on a region and the things that people care about for ongoing sustenance and survival in a region.

There are several cumulative effects initiatives happening in the region, including the Cumulative Effects Monitoring Initiative, led by Environment Canada and Climate Change, and includes input from various stakeholders, including the First Nations along this coast: Gitga'at First Nation, Gitxaała First Nation, Haisla First Nation, Kitselas First Nation, Kitsumkalum First Nation, Metlakatla First Nation.

In the Cumulative Effects film clip, **Rina Gemeinhardt (Environment, Lands and Referrals, Kitsumkalum First Nation)** and **Nicole Wallace (Consulting Biologist, Kitsumkalum First Nation),** explain how the North Coast region, and particularly the area along the Skeena River and the Skeena River estuary, is going through a period of very intense development. Many outside groups are wishing to move forward with development plans in the region, including projects such as natural gas pipelines, refineries, wind power plants and all the increased marine traffic (tankers and vessels) that accompany this development. Rina and Nicole stress the need to look at all the projects together, and to think about the impact that a lot of development happening at the same time will have on the area and ecosystem as a whole.

As **Bruce Watkinson (Marine Program Coordinator, Gitxaala Environmental Monitoring)** describes it in the film:

> *"Well, when they start having two, or three, or four, or five of these projects, the additive effect, the cumulative effect, of those projects, it needs to be examined. Both in a short-term perspective and, more importantly, I think, in a long-term perspective. What effects are these projects, as a group as a whole, what effect are they having on our environment and our resources? And our culture."*

From the Metlakatla First Nation perspective, **Taylor Zeeg (Advisor, Cumulative Effects Management Initiative, Metlakatla Stewardship Society)** shares this observation:

> *"Basically, cumulative effects are the combined effects of past, present, and future activities on the things that people care about. In our case it's what the Metlakatla membership cares about. So the starting point for us was going through a process to understand the priorities of the membership given the development context within the territory.*

One of the Metlakatla priorities is, we called it "food, social, and ceremonial activity." We loosely define that as hunting, fishing, gathering, social events, cooking, eating. So it's a broad spectrum of things. And trying to understand to what degree people are participating in these activities. And is that level of participation being negatively or positively affected by the development activity that we're seeing in the area.

So, that would have been something that sort of fits in the cultural category, but in the case of at least Metlakatla First Nations it has implications for health, economy, and social well-being as well.

Metlakatlas have always taken economic development very seriously, but it's always been said "never at the expense of stewardship." So there's all this stuff happening and the environmental assessment process tends to be focused on a single project. The process wasn't well suited to address the relationship amongst different projects and the effects that can result. That's where Cumulative Effects steps in."

From the Gitxaala First Nation perspective, **Caroline Butler (Heritage Research Coordinator, Gitxaala Environmental Monitoring)** shares this observation:

"So working with community members and working in collaboration with other nations, we have identified a long list of values. Gitxaala people harvest probably close to 100 different species from the territory. So, we've identified species of concern. We've identified critical habitats. We've identified cultural values. And, it's a case now of creating the indicators for being able to monitor those values and the impacts on them.

So, wake, for example. The community members have a lot of concern about the impacts of a wake from tanker traffic. So, for harvesters out in a small speedboat, what that means to their safety, what that means to their gear, what it means to the species on the beach, the clam beds, what it means to boats on the beach, and people on the beach. What it means to the marine archeological sites, the coastal archeological sites. So looking at the speed of the vessels and the size of the wake, the consistency of those impacts over time as the traffic increases, and how that can be managed, or mitigated, or stopped.

This is a really important time. And it's an important time for everyone to be really diligent about what happens here. There's been a lot of change here, and a lot of impacts over the last 150 years, but people have been able to maintain their way of life, and protect their territory, and protect their culture, but this is a different level of threat. So, it's really important to plan it well, and trace out all the potential impacts, and some of them are clearer. Like clear out the eelgrass. There are very clear, ecological impacts to that loss of habitat. But, what's more difficult to trace out, but equally important, is to understand how the population increase, the rise in the price of housing, the increased traffic, the size of the wake down Principe Channel, what that means to how people feel about their territory. How they are able to manage the resources."

Case Study 5: Clam Gardens

Clams were and are a vital food source of many First Nations in BC. The film clip details some research occurring in the Great Bear Sea. This research is led by Dr. Anne Salomon at Simon Fraser University. The information below is shared with permission by the Member Nations of the Nanwakolas Council – North Vancouver Island, and provides some background about the Nations and clam gardens.

First Nations' Culture, Communities & Governance

The Kwak'wala, Lik'wala and K'omoks speaking peoples were a highly stratified bilineal culture of the Pacific Northwest. Today, fifteen remaining Nations comprise the grouping known as the Kwakwaka'wakw . Each Kwakwaka'wakw Nation has its own history, culture, and governance, but remains collectively similar. Seven of these fifteen First Nations are represented through this Ha-ma-yas Marine Plan: the Mamalilikulla Qwe'Qwa'Sot'Em, Tlowitsis, Da'naxda'xw Awaetlatla, Gwa'sala-'Nakwaxda'xw, Wei Wai Kum, Kwiakah and K'omoks.

Each of the member First Nations has its own stories, songs, dances, and masks that tell of who they are and their origins. The Nations have extremely strong ties to their territories, dating back to the beginning. For example, each Nation has its own version of the great flood and how some members survived. The K'omoks First Nation tells the story through the **Legend of Queneesh (Figure 1)**:

> *"Long ago there were big cedar planked houses, totem poles and canoes in the K'omoks Valley. The nights were very quiet, except for the sounds of the water, sea birds and of hooting owls. One night an old man, Quoi Qwa Lak, had a dream. In that dream a voice told him that he must tell the chief and the K'omoks people to prepare for a great flood. Quoi Qwa Lak passed this message on and the K'omoks built canoes and packed them full of food and clothes. The young men made a strong cedar rope and took it to the top of the glacier and fastened it tightly. The people tied their canoes to the rope. Not long after, it began to rain; it rained and rained for many days. Soon there was only a little of the glacier showing. The K'omoks people were afraid. Then all of a sudden the glacier began to move. The people began to cry "White Whale, White Whale! Queneesh, Queneesh." The glacier had taken the form of a whale and saved our people. The rain stopped, and Queneesh still stands guard over the K'omoks people to this very day."*

Figure 1. K'omoks Legend of Queneesh

Similarly, each Nation has its own territory, traditions, crests, privileges, and names for its important members. Potlatches and winter ceremonial feasts are still used to conduct social, cultural, economic and political business. The Kwakwaka'wakw still have ties to their winter villages, and the clan/family seasonal camping sites, fishing places, hunting and gathering areas.

Marine resources were, and are still today, traditionally utilized through time and space cycles, reflecting Kwakwaka'wakw socio-political structures and former settlement patterns. The Kwakwaka'wakw economic life was and is (where still possible) characterized by a regular series of seasonal occupations during which marine resources are gathered and processed. The **Seasonal Use Cycle of the Kwakwaka'wakw*** illustrates the seasonal cycle and the types of resources harvested and processed at the various time of the year. Although specific activities and movements vary from one First Nation to another, in general the cycle involves a sequence of three key movements: a) from winter villages to the eulachon fisheries in the spring; b) the use of 'other' resource procurement sites during the summer and fall; and c) the return to the winter villages (now modern, permanent settlements in the case of most member Nations).

Following the two month eulachon season, people disperse to a variety of resource procurement sites. The most important are salmon fisheries sites, occupied (according to site and species) until late fall. During this period, people also harvest a range of resources from both land and sea. Some, such as berries, ground fish, rock fish and shellfish, are widely distributed and often can be gathered near the fishing stations. Occasional visits to the principle village would occur during this period of gathering, but the onset of winter completes the cycle. About the end of November, the village would be re-occupied on a full-time basis and clams and other shellfish become key sources of fresh protein. The removal of member Nations from village sites, and the effects of modern technology have altered many components of this traditional cycle. **Table 1** provides a example of resources used by Kwakwaka'wakw and Nanwakolas Member First Nations.

Table 1: Partial List of Resources Used by Kwakwaka'wakw and Nanwakolas Member First Nations

Fish Species	Shellfish and Invertebrates	Marine Mammals, Plants and Birds
Salmon (all species)	Dungeness Crab	Harbour Seal/Hair Seal
Steelhead	Snow Crab	Northern Fur Seal
Cutthroat Trout	Pacific Crab	Sea Otter
Eulachon	Clams	Dall's Porpoise
Halibut/Pacific Halibut	Horse Clam/Geoduck/Gaper/ Pacific Coast Gaper	Humpback Whale
Cod	Butter Clam/Smooth Wash-ington Clam	Minke Whale/Pike Whale/Little Piked Whale
Ling Cod	Mussels (California/Sea Mussel/Blue Mussel)	Edible Seaweed
Red Cod	Barnacle/Giant Acorn Barnacle	Kelp/Sea Wrack
Red Snapper	Basket Cockle/Heart Cockle	Bull Kelp/Bottle kelp
Black Rockfish	Abalone (Northern/Japanese)	Common Eelgrass
Yelloweye Rockfish	Prawns	Rockweed/Bladderwrack
Shiner Perch	Shrimp	
Starry Flounder	Sea Urchins	
Black Cod/Sablefish	Chitons (Black Katy/Black Leather/ Giant Pacific Chiton/ Gum Boot Chiton)	
Tuna	Octopus	
Dogfish	Sea Cucumber	
Great Sculpin/ Bullhead		
Herring/Herring Roe		
Sardines		
Eels		
Keip Greenling/ Tommy Cod		
Spotted Ratfish		

Clam Gardens

Loxiwe, or clam gardens, are a unique feature found throughout the Kwakwaka'wakw territory. Loxiwe means “place of rolling rocks together” to create a terrace or clam garden. These places of rolling rocks together create incredibly productive shellfish growing sites. The concentration of Loxiwe found in the area now called the Broughton, allows for a reliable source of protein during the difficult winter months.

Loxiwe were first created by the Elders, women and young children who would roll boulders and rocks to the edge of the lowest tide mark. Sand and silt would fill up behind the terracing toward the beach and create perfect clam habitat. This allowed clams to be easily harvested with a digging stick and the areas tended to by the owners of that specific beach.

This form of clam aquaculture began producing abundant quantities of clams as seen through shell middens along the coast. Those families who did not have rights on streams would have to rely more heavily on clams and share, trade or barter for salmon. Although salmon are critical to First Nations life, clams are a staple and the part of everyday life. There is little mention of their importance compared to salmon, but the Elders have informed us that clams have always been critical in sustaining the Kwakwaka'wakw .

> *“Productivity of clam gardens was carefully monitored and managed. To maintain the clam gardens, the sand was turned over every year or the clams at the bottom would die. The smell of a clam garden is an indicator of its health. In the past, there were guardians for each First Nation and one of their duties was to ensure the health of their First Nation's Loxiwe. If a shellfish bed was severely depleted or not suitable for harvest the guardian would speak to the chief and a ceremonial copper would be posted to warn others not to harvest from this Loxiwe.”*

Name:____________________

3.1: Great Bear Sea Case Studies

Group Members:

Case Study Topic:

1. **Provide a brief synopsis (4 – 5 sentences) of the case study:**

2. **What regions are involved?**

3. **Who (researchers, First Nations, etc.) are involved and how?**

4. **What is being researched or studied and why? Include the names of species, problems, issues, etc., as well as any specific research question(s).**

5. **Briefly share any hypotheses or research results. If these were not shared in your case study, create your own hypothesis or predictions about the what is being researched.**

6. **How does the case study draw on local or Traditional Knowledge?**

7. **How does the case study connect to biodiversity or conservation in the Great Bear Sea region?**

8. **How will this information help planning for the future?**

Name:______________________

3.2: Self-Assessment Checklist

For each statement, please rate **your** participation and contribution to the group activity. For each question, include an example of your contribution or what you wish to work on for next time.

1 = I need to work on this area.
2 = I did ok in this area.
3 = I excelled in this area.

	1	2	3	Example or wish for next time:
I was ready to work and remained focused on the task.				
I shared my ideas and opinions.				
I listened attentively and respectfully to others' ideas and opinions.				
I accepted constructive feedback and provided the same to others when possible.				
When faced with challenges, I contributed to problem solving in order to complete tasks.				
I did my fair share of the work during the activity.				

Other comments or suggestions for future learning:

Name:____________________

3.3: Group Assessment Checklist

Group Members' Names:

As a team, please rate the way **the group** worked together, and then complete the questions.

1 = We need to work on this area.
2 = We did ok in this area.
3 = We excelled in this area.

	1	2	3
We were ready to work and remained focused on the task.			
We encouraged each other to share ideas and opinions.			
We listened attentively and respectfully when individuals were sharing.			
All members were involved in decision-making.			
When faced with challenges, we worked as a team to find strategies to complete the tasks.			

Describe one thing your group did really well:

Describe one thing your group could improve for next time, and the strategy you might use: