ARCTIC MARINE SCIENCE CURRICULUM

MODULE 4

HABITATS

TEACHER'S GUIDE

2001

Prepared for:
Fisheries and Oceans Canada
Northwest Territories Dept. of Education, Culture and Employment
Nunavut Department of Education
Yukon Department of Education

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MODULE 4

TEACHER'S GUIDE

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SLO 4–65 Describe and illustrate the process through which carbon, nitrogen, and oxygen are cycled through a polynya using a food web.

RECOMMENDED RESOURCES

Print

Castro, Peter and Michael Huber. Marine Biology. Toronto, ON: Wm.C. Brown, 1997.

Dando, Marc and Michael Burchett, contributors, Geoffrey Waller, editor. SeaLife, a complete guide to the marine environment. US: Smithsonian Institution Press, 1996.

Grace, Eric, et al. Sciencepower 10. Toronto, ON: McGraw-Hill Ryerson, 2000.

Johnson, George B., and Peter H. Raven. Biology: Principles and Explorations. Holt, Rinehardt and Winston, 1996.

Longhurst, Alan. Ecological Geography of the Sea. San Diego: Academic Press, 1998.

Matthiessen, Peter. The Wind Birds, shorebirds of north america. Vermont: Chapters Publishing Ltd. 1994.

McDonald, Miriam, Lucassie Arragutainaq, and Zack Novalinga. Voices from the Bay. Ottawa, ON: Canadian Arctic Resources Committee Environmental Committee of Municipality of Sanikiluaq, 1997.

Pielou, E.C. A Naturalist's Guide to the Arctic. London: The University of Chicago Press Ltd, 1994.

Pielou, E. C. Fresh Water. Chicago: The University of Chicago Press, 1998.

Ritter, Bob, et al. Nelson Science 10. Scarborough, ON: Nelson Thomson Learning, 2001.

Smith, Robert Leo, and Thomas M. Smith. Elements of Ecology, 4th edition. San Francisco: Benjamin/Cummings Science Publishing, 2000.

Sumich, James L. and Gordon H. Dudley. Laboratory and Field Investigations in Marine Biology. ON: Wm. C. Brown Publishers, 1980.

Thorne-Miller, Boyce. The Living Ocean, understanding and protecting marine biodiversity. Washington, DC: Island Press, 1999.

Thurman, Harold V. Introductory Oceanography. Ohio: Charles E. Merrill Publishing Company, 1975.

Webber, Herbert H. and Harold V. Thurman. Marine Biology. New York, NY: HarperCollins, 1991.

Young, Steven B. To The Arctic, an introduction to the far northern world. US: Wiley Science Editions, John Wiley and Sons, Inc. 1989.

Websites

Referenced throughout Module.

Great site for the breakdown of the Arctic Oceans Ecozones
http://www.cprc.uregina.ca/ccea/ecozones/marine.html

Canadian Arctic Profiles
This web site provides information on a variety of topics relating to the Canadian Arctic. The site is dynamic and the range of topics and the depth of treatment will be augmented over time under the auspices of the Digital Collection Program of Industry Canada.
http://collections.ic.gc.ca/arctic/english.htm

Canadian Polar Continental Shelf Project
Gives information about on-going research projects in the Canadian Arctic.
http://polar.rncan.gc.ca/home_e.html

Cape Parry Migratory Bird Sanctuary Home Page
http://collections.ic.gc.ca/sanctuaries/nwt/parry.htm

DFO
DFO Marine Habitat and Science Division Website
http://www.ios.bc.ca/ios/mehsd/hottopics/default.htm

Environment Canada
Marine and terrestrial ecozones. Good general information is found here.
http://www.ec.gc.ca/soer-ree/English/vignettes/marine/marine.cfm

Geological Survey of Canada (GSC)
Provides good Canadian landscape images
http://sts.gsc.nrcan.gc.ca/clf/home.asp

Minerals Management Service – Alaska OCS Region
Environmental studies section
http://www.mms.gov/alaska/ess/index.htm

Marine Habitat Main Page – USGS (science for a changing world)
http://abscweb.wr.usgs.gov/research/seabird&foragefish/marinehabitat/home.html

Natural Resources Canada
Earth Sciences Sector – Information Resources links to Canadian government Science Sites.
http://collections.ic.gc.ca/sanctuaries/nwt/parry.htm

NOAA
The National Oceanographic Data Center (NODC) is one of three NOAA environmental data centers, and serves as a national repository and dissemination facility for global ocean data.
http://www.nodc.noaa.gov/

NOW – The North Water Polynya Study
Is an international study site. There is good reference material for the teacher and advanced students.
http://www.fsg.ulaval.ca/giroq/now/scien.htm

Nunavut Research Institute
This is a link to the research studies at the institute for those looking for more detailed information.
http://pooka.nunanet.com/~research/docs/98compendium.htm#_Toc487013545

Ocean98
The home page for Ocean98. This site offers some good general information about the world's oceans.
http://www.ocean98.org/fact.htm#H

Parks Canada
Parks Canada Home Page
http://www.parkscanada.pch.gc.ca/np/np_e.htm

Good introduction to Canada's Arctic Marine Environment – part of the Canada's National Marine Conservation Areas System Plan
http://parkscanada.pch.gc.ca/nmca/nmca/arctic/index.htm

The Bridge
Teachers will find a selection of the best online resources for marine science education. This site has been built by educators and scientists.
http://www.vims.edu/bridge/index.html

University of Guelph
This site has good overview information about the Arctic environment and ecozones.
http://www.arctic.uoguelph.ca/environments/sidemarine.htm

PART A: COASTAL HABITATS

INTRODUCTION TO MARINE HABITATS

NOTE: Not every community will contain all of the geographical features presented in this module. It is highly recommended that **all** students study the first section, Coastal Habitats *(Section 1.9),* an introduction to all of the coastal habitats presented in this module, as well as the sections Open Ocean *(Section 5.0) and* Polynyas *(Section 6.0)*. Teachers have the option of selecting the appropriate sub–sections that apply to their own community and environment, or completing all of the sections in this module. Because it is not intended that all students complete all sections, there is some overlap in the suggested activities. This is done to ensure students have particular learning experience not matter what habitat they study.

COMMUNITY USE OF THE COASTAL AREA

SLO: Examine the community use of coastal areas.	
Essential question:	*Does the community use the coastal area?*
Recommended Time:	1 class

The extent to which a community uses its coastal resources will vary. A list of possible uses for the coastal area has been given as a guide. The class should research this topic and make a wall poster that illustrates how their community uses this resource.

Possible uses:

- Recreational boating
- Commercial and recreational fishing
- Transportation
- Eco-tourism businesses
- Waste disposal
- Dumping of garbage
- Source of energy
- Tourist attraction

1.0 THE COAST

1.1 PHYSICAL CHARACTERISTICS OF COASTAL AREAS

SLO 4-01:	Explain the key physical characteristics of a coastal area.
SLO 4-02:	Explain the importance of coastal areas in local and global ecosystems.
SLO 4-03:	Explain the dynamics of coastal erosion and deposition.
SLO 4-04:	Examine the process of beach formation.
SLO 4-05:	Investigate the zones of coastal areas.
SLO 4-06:	Examine changes to coastal areas.
SLO 4-07:	Define isostatic rebound.
Essential Question:	***What are the key physical characteristics of a coastal area and what forces are responsible for their formation and continual evolution?***
Recommended Time:	3 classes

Useful resources:

The following URL gives a good look at the biology of a Salt Marsh.
http://home.istar.ca/~eac_hfx/MIC/Projects/salt–webpage/menu.html

The Department of Fisheries and Oceans Web site contains information about all habitats
http://www.gfc.dfo.ca/habitat/aifm12.htm

Lab 1 – Field Observations (Refer to Lab Manual)

This lab information sheet provides a template for carrying out field observations of local marine ecosystems. It is recommended that students use this guide to carry out an initial field study of a local area early on in this module to practice their observation skills. As the module progresses, they will complete increasingly detailed observations and relate the information in the student guide to what they see outdoors. Students should have the opportunity to carry out field studies in several different study areas to allow comparisons. In addition, students will also have the opportunity to carry out water testing activities (Labs 3 to 6).

Practicing the Protocols

Protocols related to water testing and measurements are provided in Labs 3 to 6 in the Lab Manual. These protocols are taken from the GLOBE Program website, located at:
www.globe.gov.

In order for students to develop skills related to these protocols, a number of practice stations can be created.

- Salinity
- Dissolved oxygen
- Water temperature
- Water transparency

These stations reflect the labs that students will be undertaking later in the module. *Appendix 1* provides teacher and student information needed to carry out these activities. Teachers should decide how to incorporate these activities into the classroom, and whether all of them are required. Students will need to refer to the related labs in their Lab Manuals for the protocols to complete these activities.

Labs 3 to 6 (Refer to Lab Manual)

Labs 3 and 6 address the measurement skills students undertook as part of the previous activity, Practicing the Protocols. If students do not have the opportunity to practice these skills beforehand, more time will be required to learn these skills, particularly accuracy, during the labs.

Teachers need to determine how and when these labs will be undertaken. A number of samples can be collected from different locations. Specific measurements (e.g. salinity) can be undertaken as needed. Or, following a field trip to a particular ecosystem, all of the tests could be carried out on the samples collected. These can later be compared to samples taken from another area.

All of these labs require that water samples be taken from a local water source. If some of these labs are scheduled during the winter, then additional water samples should be collected. Water samples taken through the ice will provide constant, reliable results if samples are to be compared and put into a database of results. Connection to web pages from other schools would also facilitate the sharing and comparison of data. Data should also be recorded in the Community Profile book to facilitate multi-year comparisons.

Some Hints:

- Sampling Techniques: Some general guidelines for water sampling were included in the Teachers Guide for Module 1. Use those protocols to sample water from a coastal area.
- Extreme weather or severe ice conditions may prevent students from taking their own water samples. Always have an alternative plan.
- Teachers do have the option of collecting the samples.
- Obtain samples from local fishermen either in the summer or winter.
- Collect/compare data from the Internet
- Connections with the local community can have positive effects on this program.
- Ice augers may be borrowed from HTOs and Wildlife Officers.
- A data sheet has been included in the Student Lab Manual that has space for collecting the following properties of water: temperature, dissolved oxygen, salinity, alkalinity, and water transparency. *NOTE:* students have already collected data related to pH in Module

1 and may choose to repeat that measurement here. Students are not required to complete measurements related to electrical conductivity and nitrate.

Assessment Suggestion: Refer to the appendix for the following tools: Conducting Labs Observation Checklist and Self and Teacher Rating Scale.

Erosion and Deposition KWL

Use this activity to allow students to access their prior knowledge related to erosion and deposition. Either a simple KWL can be used (what do you know, what do you want to know, and later – what did you learn); or a variation which adds "what do you need to know".

Lab 2 - How to Make a Delta (Refer to Lab Manual)

- Many variables can be changed in this activity to make it simple or complex. Students can be as creative as they wish within the confines of the classroom.
- If completing this activity outside, students should observe the spring run-off to see the formation of mini-deltas. Observations could be made of the process over a short period of time.
- Another option for this activity is for the teacher to pose the problem and students design a practical solution.
- More realistic simulations can be performed if the tray on which the delta forms is large. Additional variables can then be changed:
    - obstructions set onto the pan,
    - tilting the pan,
    - changing the angle from flat to inclined.
- By having a continuous flow of water down the trough, the affects of a constant flow are observed. However, a constant flow of water will require catching the water in a measured container to measure the flow's volume. Remember, if you have the water run down the trough with the sand in the tray, the sand will introduce an error into the true volume of the water. Have students find ways to reduce the errors.
- Observation could include a drawing, a written report, or a video.

Assessment Suggestion: Students could make a video, a short story, or a play that connects to their community. A rubric reflecting the activity's focus could be used to assess student work. (A great science fair project for a group of students.)

Using Maps

Using a topographical map of your local area, identify coastal features (cliffs, beaches, etc.) that you have seen while travelling. Include the traditional names for these places.

Local Elder

Students should ask Elders in the community if they remember significant natural changes that have occurred to the coastal shoreline. Ask them to provide an explanation for these changes if there were any.

E Check for Understanding

1. The community you live in is unique. What features are present in the coastal area nearest to you? *(Answers will vary.)*
2. What would be considered a high-energy beach? *(A high energy beach would be exposed to the open ocean causing maximum erosional changes.)*
3. What factors affect the amount of wave erosion? Which, if any, of these factors are present in your area? *(Factors are: the degree of exposure to the open ocean, the tidal range, the composition of the bed rock, freshwater out flow, ice formation.)*
4. Briefly describe any depositional features present in your community. *(Answers will vary.)*
5. Talk to community members about the difficulties of travelling in coastal areas due to different coastal formations or the presence

1.2 BIOLOGICAL CHARACTERISTICS

SLO 4-08:	Describe the major coastal ecosystem/zones in the coastal area.
SLO 4-09:	Examine and classify benthic organisms in the coastal area.
SLO 4-10:	Examine the biodiversity of a coastal area.
Essential question:	***What organisms are found in coastal areas?***
Recommended Time:	1 class

Lab 7 - Macroinvertebrate Discovery Lab (Refer to Lab Manual)

In this discovery lab, students will establish a diversity index for benthic macroinvertebrates by sorting and counting organisms collected from the site. During the process they will become familiar with many taxa of macroinvertebrates. Students will then investigate the relationship between the taxa they found and their water chemistry measurements.

1.3 NUTRIENT CYCLING

SLO 4-11:	Examine nutrient cycling through coastal areas.
Essential Question:	***How are nutrients cycled in coastal areas?***
Recommended Time:	1/2 class

Cycling of Nutrients

Refer students back to Module 2 where nutrient cycles were first introduced. Have students construct a prior knowledge chart to activate that information and then, at a later point, to record what they have learned.

Start with these headings:
- Know now (draw)
- Know now (list)
- Need to know

Add these heading following the learning experiences:
- List what you have learned
- Final concept map or drawing

Students could also use an adaptation of a concept map to illustrate how the three elements, oxygen, nitrogen and carbon are cycled.

1.4 FACTORS AFFECTING COASTAL AREAS

SLO 4-12:	Examine factors that contribute both positively and negatively to coastal areas.
SLO 4-13:	Explain the impact of contaminants on coastal areas.
Essential question:	***What factors affect the coastal zone?***
Recommended Time:	1/2 class

Compare and Contrast

Students can use the Concept Relationship or Compare and Contrast Frame *(Appendix 2*) to summarize factors that affect the shoreline. Special attention should be given to ice effects on the local coastal landscape.

Comments: Bioaccumulation of contaminants was discussed in detail in module 2, and will be addressed again in Module 5. Students should refer back to the information to see how it relates to the coastal area.

Module 2 contained a number of activities around the problem of local contaminants. If they were not completed in that module, they should be done here but adapted specifically to the coastal area.

NOTE: The student learning outcomes and associated activities for the coastal ecosystem studies in sections 2, 3 and 4 are very similar. It is **not** intended that students study all the coastal ecosystems and repeat similar activities, but that classes select which ecosystems are most relevant to focus on. Once this selection has been made, teachers should preview the learning activities from all three sections, mixing-and-matching them to suite their needs.

2.0 ESTUARIES

2.1 IMPORTANCE OF ESTUARIES

SLO 4-14:	Explain and examine the importance of estuaries in local and global ecosystems.
SLO 4-15:	Examine the community use of estuaries.
SLO 4-16:	Investigate and defend the community use of an estuary.
Essential Question:	***Why are estuaries important?***
Recommended Time:	1-2 classes

This section overlaps with 1.1, but deals specifically with estuaries. If community uses of coastal areas were not identified in section 1, they should be identified now with an estuary focus.

Elders Sharing

Have Elders visit the class or accompany the class on a field trip to share their knowledge about estuaries.

Debate

Identify a local issue that has potential impact on an estuary. Have students gather information on the issues and perspectives, and conduct a debate. This activity could also take place in conjunction with the Journey to the Sea/We All Live Downstream! provided in Section 2.3.

An alternative is to either take part in local meetings regarding an issue or write letters indicating their position.

2.2 PHYSICAL CHARACTERISTICS OF ESTUARIES

SLO 4-17:	Explain the key physical characteristics of estuaries.
SLO 4-18:	Explain and examine how estuaries are formed.
SLO 4-19:	Students will examine and investigate the key physical characteristics of marine and freshwater estuaries.
SLO 4-20:	Examine the roles that ice plays in estuaries.
Essential Question:	***What is an estuary and how was it formed?***
Recommended time:	2-3 classes

Identification of a Watershed

An estuary collects water from the surrounding watershed. To understand how water is collected, students should plot their own watershed.

Background Information

Watersheds describe the flow of water within a region toward a common destination. Small watersheds lead to larger and larger watersheds, eventually into the oceans of the world. Watersheds enter the world's oceans through estuaries.

Students should understand how watersheds move water to their local estuary. Once they have traced the water trail and the trail of potential pollutants to their estuary, they will begin to appreciate the need for environmental controls and water resource management.

Introduce students to watersheds by having them locate the following rivers on a map of Canada: Mackenzie, Hayes, Nelson River, Coppermine, and Thelon. Remind students that water from these great northern rivers flows into the Arctic Ocean or Hudson Bay.

If students do not already have copies of Arctic and local maps, they can be found at the following Arctic websites:

Northwest Territories:
www.nwttravel.nt.ca

Nunavut:
www.gov.nu.ca

Yukon:
www.gov.yk.ca

Lab 8 - Four Estuaries (Refer to Lab Manual)

This lab is quite involved and will take a bit of preparation. It is well worth the effort. This lab can also be used as a design project where students either design the labs or make improvements to the existing procedure. This series of four activities will give students an appreciation for the differences between the four types of estuaries.

2.3 BIOLOGICAL CHARACTERISTICS OF AN ESTUARY

SLO 4-21:	Explain the key biological characteristics of estuaries.
SLO 4-22:	Examine the biodiversity of estuaries.
SLO 4-23:	Examine and classify the benthic organisms in the estuaries
SLO 4-24:	Examine the cycling of nutrients through estuaries
Essential Question:	***What organisms make their homes in estuaries?***
Recommended time:	1-3 classes

Observation Activity

An activity that can be done at any point is to use the eyes and ears of students in the class to establish a record of the various organisms living in your community estuary. The observation can be as simple or as complex as required to fit student interests. The records that are kept can be either in the form of a list with a description or a pictorial account with photographs, sketches, video, etc. To be completed correctly, sightings should be marked on a local or regional map. Local biologists may be asked to confirm the identity of the various animals observed throughout the year.

Observational Activity Extension

Once students have established a list of animals that live in an estuary, they should then organize the organisms into ecological groups based on the food webs that can be created from the animals they identified.

Lab - 7 Macroinvertebrate Discovery (Refer to Lab Manual)

If students did not complete this lab in the section under Coastal Area they should do it now. In this discovery lab, students will establish a diversity index for benthic macroinvertebrates by sorting and counting organisms collected from the site. In the process they will become familiar with many taxa of macroinvertebrates. Students will then investigate the relationship between the taxa they found and their water chemistry measurements.

2.4 FACTORS AFFECTING ESTUARIES

SLO 4-25:	Examine factors that contribute both positively and negatively to estuaries.
Essential Question:	***What factors affect estuaries?***
Recommended time:	1 class

Journey to the Sea / We all live downstream!

Obtain topographical maps of your local area that include part of a watershed area leading to an estuary. These maps can be obtained from the Department of Resources, Wildlife, and Economic Development in the Northwest Territories, and the Department of Sustainable Development in Nunauvt. Have students use contour lines to establish points of elevation that will provide clues as to the direction of water flow through the watershed. Have students mark the water flow direction by arrows.

Once students have drawn the directional flow arrows, have them mark the location of their home, school, garbage dump, sewage treatment plant, water wells, etc.

Extension

Now that students have already discussed contaminants and pollutants to their local ecosystem, an extension to this activity is to have students their own community's potential sources of pollution for their watershed. Contact or interviews could be made with community Elders and leaders, local government offices, or community library. Some potential sources of pollution might be: household chemicals, septic tanks, automobile garages, pets and other animals, irrigation systems, erosion sediments, fertilizers, pesticides, recreational boating, marine dumping.

Compare and Contrast

Students can use the Concept Frame (*Appendix 2*) to summarize factors that affect the shoreline. Special attention should be given to ice effects on the local coastal landscape.

3.0 SALT MARSHES AND LAGOONS

3.1 IMPORTANCE OF SALT MARSHES AND LAGOONS

SLO 4-26:	Explain the ecological significance of salt marshes.
SLO 4-27:	Explain and illustrate the role of slat marshes in local and global ecosystems.
SLO 4-28:	Investigate and defend the community use of local salt marshes and lagoons.
SLO 4-29:	Confidently evaluate evidence and consider alternative perspectives, ideas, and explanations.
Essential Question:	***Why are salt marshes and lagoons important and how can we make responsible decisions related to their use.***
Recommended Time:	2 classes

Identifying Local Significance

Investigate local uses of salt marshes and materials that are used locally from the marsh to produce consumer goods.

Public Hearing

As the module progresses, have students gather information for organizing and participating in a public hearing to determine if a sewage lagoon should be developed close to a local salt marsh. Ensure that different perspectives are identified and taken on by each student/student group. They should address the ecological, social and environmental aspects of the situation and the resulting decision. This activity could also be saved for module 5 where students study local governance of ocean resources.

3.2 PHYSICAL CHARACTERISTICS OF SALT MARSHES AND LAGOONS

SLO 4-30:	Examine and investigate the key physical characteristics of salt marshes including ice, salt and tides.
SLO 4-31:	Explain and examine the role of sediment in forming a salt marsh.
SLO 4-32:	Investigate the transition zones between tidal flats, salt marshes and the land.
Essential Question:	***What are salt marshes and lagoons and how were they formed?***
Recommended Time:	2 classes

Are They All the Same?

Have students apply their skills in determining salinity to compare the level of salinity in several salt marshes in their area, or share data with other schools via the internet. Students should analyze the results and try to identify reasons for any differences. Comparisons can also be made regarding representative food chains.

Comic Strip

Have students create a comic strip or flip book for younger children that illustrates the changes that take place in a salt marsh with the tides; OR changes evident between the summer and winter months.

Sources of Information

Salt marsh web page
http://home.istar.ca/~eac_hfx/MIC/Projects/salt–webpage/menu.html

Department of Fisheries and Oceans Website
http://www.gfc.dfo.ca/habitat/aifm12.htm

Studying Transition Zones

Have students make field observations related to the transition zones between tidal flats, salt marshes; as well as the land and the organisms that inhabit them. From these observations, have students create a set of characteristics that describe the transition areas.

3.3 BIOLOGICAL CHARACTERISTICS OF SALT MARSHES AND LAGOONS

SLO 4-33:	Examine the biodiversity of a salt marsh.
SLO 4-34:	Examine and classify the benthic organisms in the salt marsh.
Essential Question:	***What types of flora and fauna inhabit salt marshes?***
Recommended Time:	Field activity

Statistical Sampling

Have student groups mark with string and stakes 1 m^2 plots of salt marsh. Make sure they have some protection from mosquitoes and other bugs. Have each student group observe and classify organisms within that measured plot of land. Plants can also be included. Teachers can predetermine the level of sophistication of the organism sampling. Have students begin with large, easily recognized insects and go on from there. Once a number has been agreed upon for a specific organism, the group can then calculate the number of these organisms in the total area by diving the 1 m^2 plot into the total area, multiplying that number by the number of organisms found in the 1 m^2 area. The final number will represent a statistical average for that species.

4.0 TIDAL FLATS

4.1 IMPORTANCE OF TIDAL FLATS

SLO 4-35:	Explain and illustrate the role of tidal flats in local and global ecosystems.
SLO 4-36:	Explain and discuss the ecological significance of tidal flats.
SLO 4-37:	Investigate and defend the community use of the tidal flats.

Essential Question: ***Why are tidal flats important?***

Recommended Time: Determined by community involvement.

Identifying Local Significance

Investigate local uses of tidal flats.

Public Hearing

Have students organize and participate in a public hearing to determine if a sewage lagoon should be developed close to a local tidal flat. Ensure that different perspectives are identified and taken on by each student/student group. They should address the ecological, social and environmental aspects of the situation and the resulting decision. This activity could be saved for module 5 where students study local governance of ocean resources.

4.2 PHYSICAL CHARACTERISTICS OF TIDAL FLATS

SLO 4-38:	Students will examine and investigate the key physical characteristics of tidal flats including ice, salt and tides.
SLO 4-39:	Explain and illustrate how tidal flats are formed.
SLO 4-40:	Examine the dynamics of ice on a tidal flat.
SLO 4-41:	Investigate the transition zones between tidal flats, salt marshes and estuaries.
SLO 4-42:	Examine and investigate zones within a tidal flat.
Essential Question*:*	**What are tidal flats and how were they formed?**
Recommended Time:	Dependent on selection of activities.

Refer back to activities in the earlier sections of this module. They can be applied to the tidal flats ecosystem as well. Several have been repeated below.

Lab Activities

There are a number of labs and activities that were described in the overview to coastal areas, section 1.1. These labs can be repeated here using water samples obtained from Tidal Flats. See the notes provided in section 1.1.

Are They All the Same?

If possible, compare the level of salinity in several tidal flats. Sharing data from different schools via the internet is an option.

Comic Strip

Have students create a comic strip or flip book for younger children that illustrates the changes that take place in a tidal flat with the tides; OR changes evident between the summer and winter months.

Observational Tide

Use student groups to observe the times of the different tides together with a measure of their height. Compile this information and compare data with difference locations. Have students draw conclusions from the data.

Studying Transition Zones

Have students make field observations related to the transition that occurs between tidal flats, salt marshes, and the land and the organisms that inhabit these transition zones. From these observations, have students create a set of characteristics that describe the transition areas.

4.3 BIOLOGICAL CHARACTERISTICS OF TIDAL FLATS

SLO 4-43: Explain the key biological characteristics of tidal flats.
SLO 4-44: Examine the biodiversity of tidal flats.
SLO 4-45: Examine and classify the benthic organisms in the tidal flats.

Essential Question: ***What types of flora and fauna inhabit salt marshes?***

Recommended Time: 1 class plus field study

Species Profile

Complete a species profile of local tidal flats including diagrams of some of the key species. This should be done as part of a field study. If students do not have access to a tidal flat, they could search on the net, consult experts, etc. Use microscopes to investigate the microscopic organisms present.

4.4 FACTORS AFFECTING TIDAL FLATS

SLO 4-46: Explain and discuss the impact of contaminants on tidal flats.

Essential Question: ***What factors affect tidal flats?***

Recommended Time: 1 class

Comments Re: Contaminants

Bioaccumulation of contaminants was discussed in detail in module 2, and will be addressed again in Module 5. Students should refer back to the information to see how it relates to the tidal flats area.

Module 2 contained a number of activities around the problem of local contaminants. If they were not completed with that module, they could be now, but adapted specifically to the tidal flats area.

PART B – OPEN OCEAN

5.0 OPEN OCEAN

INTRODUCTION

All students should study this open ocean section as it is a major factor in the lifestyle of humans and animals of the North. The optional section that follows covers polynyas, which are not necessarily common to all communities in the Arctic but are extremely important to the animal life of the Arctic and the aboriginal people that live off the land.

Topics like the cycling of nutrients, the effect of contaminants, and benthic organisms in the ocean have been discussed in modules 2 and 3 and will not be covered again in this section.

5.1 IMPORTANCE OF THE OPEN OCEAN

SLO 4-47:	Investigate and discuss the human use of the shelf and open ocean.
Essential Question:	***How do humans use the shelf and open ocean?***
Recommended Time:	1 class

Illustrating the Open Ocean

The class should research the importance of the open ocean and make a wall poster that illustrates how their community uses this resource.

5.2 PHYSICAL CHARACTERISTICS OF THE OPEN OCEAN

SLO 4-48:	Explain the key physical characteristics of open ocean
SLO 4-49:	Explain the formation of the continental shelf.
SLO 4-50:	Examine the role of ice on the shelf and open ocean.
Essential Question:	***What are the characteristics of the open ocean?***
Recommended time:	2 classes

Concept Map

This section contains a lot of information. Students will need to identify and understand the big picture concepts before they will be able to make sense out of the details. A concept map is intended to help students identify the key vocabulary for a topic and the relationships between terms within a topic.

KWL application

Use a KWL sheet to identify the existing knowledge of geological events, and then show students how it applies to an Arctic shelf.

Contacting Elders

Aboriginal peoples of the Arctic have used the open ocean for generations. Community Elders would be the best source of information of how ice affects the open ocean. Student discussions with several of the local Elders are vital.

5.3 THE BIOLOGY OF THE OPEN OCEAN

SLO 4-51:	Explain the key biological characteristics of an open ocean.
SLO 4-52:	Research and discuss the biodiversity of the continental shelf.
Essential Question:	***What is the biology of the open ocean?***
Recommended time:	2 classes

The information presented here only scratches the surface of what is currently available. An attempt has been made to provide students with an overview of the aquatic organisms. There is, once again, a lot of content, but it is focused on the Arctic. An activity that helps students understand the big picture, then the details is a concept map.

5.4 FACTORS THAT AFFECT THE OPEN OCEAN

SLO 4-53:	Examine factors that contribute both positively and negatively to the open ocean.
Essential Question:	***What factors affect the open ocean?***
Recommended time:	1/2 class

Compare and Contrast

Students can use the Concept Relationship (*see Appendix 2*) or Compare and Contrast approach to summarize the factors that affect the shoreline. Special attention should be given to ice effects on the open ocean.

6.0 POLYNYAS

6.1 IMPORTANCE OF POLYNYAS

SLO 4-54:	Explain ecological significance of polynyas
Recommended Time:	1-2 classes

Class Discussion Topic

Are polynyas still important to the community or has modern technology and 'progress' made them less useful and less needed? This could be a class debate, some research could be done in the community and then the various arguments presented to the class.

6.2 PHYSICAL CHARACTERISTICS OF POLYNYAS

SLO 4-55:	Explain and demonstrate the formation of polynyas.
SLO 4-56:	Examine the key physical characteristics and dynamics of polynyas.
SLO 4-57:	Examine the location and types of polynyas
SLO 4-58:	Investigate the methods used to classify polynyas.
Essential Question:	***What is a polynya?***
Recommended time:	4 classes

The following group activity could be used as a review or to summarize all of the information at the end of this section. If students know enough about polynyas already, the activity could be completed before starting this unit on polynyas.

Group Activity

Students are formed into to their cooperative groups and given a piece of paper. Each group is asked to write one fact about polynyas on their sheet. The sheets are then placed on the walls around the room. The groups are then asked to rotate around the room to each sheet. As they reach each sheet, the group adds a different fact about polynyas to the list already there.

Internet Activity

The following Internet site contains a large amount of information about Arctic polynyas. The information on this site is written for the International North Water Polynya Study (NOW)

http://www.fsg.ulaval.ca/giroq/now/scien.htm

The diagram in the Student Guide shows how the two types of polynyas are formed. Students should examine and study this diagram before reading the description in their notes. Thermohaline circulation was discussed in the first module on Basic Oceanography. Students in areas where polynyas are present should ask Hunters and Elders how they are formed.

Class Demonstration

It is possible to demonstrate the formation of a sensible heat polynya. A water immersion heater is placed into a container of water. Put the container into a situation where it will freeze (a freezer or, if it is winter, outside). If the sides of the container are insulated, only the top of the water will freeze. When the thickness of the ice is about 2 or 3 centimeters, turn the immersion heater on and the ice will slowly melt from the bottom up.
NOTE: Make sure that the immersion heater is correctly wired and insulated prior to the experiment.

Compare and Contrast

Have students write a summary paper to compare and contrast the different ways polynyas form.

The map in the Student Guide has been taken from the International North Water Polynya Study (NOW). It provides a starting point for locating and characterizing Arctic polynyas. Additional Arctic maps can be obtained from both local and Territorial governments.

Map Plotting

Students should research and find as many polynyas as possible, marking their location – and what type they are – on a map of the local area.

Information about the location of polynyas can be obtained from local Elders as well as Fisheries and Oceans Canada.

The web site for Fisheries and Oceans, Government of Canada is:

http://www.dfo–mpo.gc.ca/

Community / Class Discussion

Find out from local Elders if any changes have occurred in local polynyas including: location, size, formation, productivity, numbers and type of organisms in and around the polynyas. A class or community Elder discussion could examine why these changes are happening and pose possible explanations and/or solutions to these changes.

E Check for Understanding

1. Briefly describe a local polynya. *(Answers will vary with the location of each community, However, in general, a polynya is an irregularly shaped opening encased in ice).*
2. What are the different aboriginal names for a polynya? *(Answers will vary.)*
3. What are the two ways in which a polynya can form? *(Very simply, a sensible heat polynya forms when warmer water from an upwelling keeps ice from forming whereas a latent heat polynya forms because wind prevents the formation of ice.)*
4. How does the nearest polynya to your community form? *(Answers will vary.)*

6.3 BIOLOGICAL CHARACTERISTICS OF POLYNYAS

SLO 4-59:	Explain the key biological characteristics of a polynya.
SLO 4-60:	Compare and contract the biodiversity of a polynya.
Essential Question:	***What organisms are found in and around polynyas?***
Recommended time:	1 class

The next four sections essentially deal with the diversity of life in and around polynyas.

Students should be aware of the term benthos as representing the organisms that live on the bottom of the ocean, sea, lake, etc. However, now the term is used to represent the life that exists on the underside of Arctic ice.

It is important that students are able to differentiate between the two types of polynya. The latent heat polynya is usually less productive than the sensible heat polynya due to the disturbance of the water column by the same wind that keeps the polynya open.

At this point in the course, students will have drawn a lot of food webs / chains but it is still the best way of illustrating organisms within a polynya. A variation on a theme might be to have photographs or animal models or animal masks placed on the web.

By now, most of the activities like this one will be in the various languages available within the class.

6.4 HOW IMPORTANT ARE POLYNYAS TO THE ARCTIC?

SLO 4-61:	Examine the cycling of nutrients through polynyas
SLO 4-62:	Investigate the process through which carbon is cycled through a polynya ecosystem.
SLO 4-63:	Investigate the process through which nitrogen is cycled through a polynya ecosystem.
SLO 4-64:	Investigate the process through which oxygen is cycled through a polynya ecosystem.
SLO 4-65:	Describe and illustrate the process through which carbon, nitrogen, and oxygen are cycled through a polynya using a food web.
Essential Question :	***How are nutrients cycled within a polynya?***
Recommended time:	1/2 class

Students should refer back to Module 3 where they studied oxygen, carbon, and nitrogen cycling. Using the food webs they made for polynyas, they will see how these nutrients are cycled.

E Check For Understanding

1. What is the cause of an inverted benthos? (*Ice algae grow on the underside of ice that contacts the water. This alga forms the basis for a benthic community of organisms that use the algae as their primary food.)*
2. Why is the productivity time of a latent heat polynya less than a sensible heat polynya? (*When wind blows across the water to keep is from freezing it also disturbs the water column which prevents the normal layering of nutrients and productivity is reduced.)*
3. If polynyas did not form, what effect would it have on the Arctic? *(This question should be answered after the class discussion with local Elders.)*

APPENDICES

APPENDIX 1: PRACTICING PROTOCOLS
(Source: GLOBE www.globe.gov)

OVERVIEW

Groups of students will rotate among measurement stations for each of the protocols that will be performed by the class. They will practice using the instrument or kit and protocol for that particular measurement, exploring sources of variation and error. The activity concludes with students testing water samples brought from a variety of places (home, yard, puddles, brooks, etc.).

If you have enough instruments and kits, you may want to focus on a subset of the measurements during a given class period in order to simplify the discussion.

PURPOSE

To have students:

- Learn how to use each of the hydrology instruments correctly
- Explore the ranges of measurements possible with each instrument
- Use each instrument as directed in the protocol
- Understand the importance of quality control

TIME

Three to four class periods

KEY CONCEPTS

- Quality assurance
- Quality control
- Reliability
- Accuracy
- Protocol
- Calibration

SKILLS

- *Following* directions carefully
- *Performing* measurements

MATERIALS AND TOOLS

Refer to the Student Lab Manual for the instruments, equipment and kits required for each protocol (Labs 3 to 6).

- One bucket of tap water
- Transparency: green food color, spoonful of silt
- Salinity: distilled water, salt, ice
- Copies of Hydrology Investigation Student Activity Sheets
- pH: samples of vinegar water, distilled water, milk, juice, soda pop, etc.
- Temperature: ice

PREPARATION

Ask students to bring in water samples from their home and/or yard.
Set up measurement stations for each of the protocols your students will be performing. For each station you will need:

- Equipment and instruments to perform the measurement
- One copy of the protocol to be posted at the station
- Copies of the Hydrology Investigation Student Activity Sheet.
- Fill a bucket with tap water at the beginning of the day. Allow it to sit until class. Record the time the bucket was filled on a piece of tape attached to the bucket.
- Fill a Dissolved Oxygen sample bottle at the same time and preserve the sample as directed in the protocol. Record the time on the sample bottle label.

BACKGROUND

A quality assurance and quality control (QA/QC) plan is necessary to ensure test results are as accurate and precise as possible. Accuracy refers to how close a measurement is to true value. Precision means the ability to obtain consistent results. Desired accuracy, precision and reliability are ensured by:

- Careful calibration, use, and maintenance of testing equipment
- Following the specific directions of a protocol exactly as described
- Repeating measurements to ensure that they are within acceptable limits
- Minimizing contamination of samples, stock chemicals and testing equipment
- Keeping track of samples

Together these steps help make the data you collect valid, valuable and meaningful.

CALIBRATION

Calibration is a procedure used to check the accuracy of testing equipment. To assure that the equipment is functioning properly, a solution of known value is tested. Calibration procedures vary among the measurements and are detailed in each protocol.

SAFETY

Consult Material Science Data Sheets (MSDS) that come with the kits and buffers. Also consult your local school district's safety procedure guidelines.

PROCEDURE

1. Divide the students into small groups, optimally three per group. Checking each other's work, students should take turns reading directions, making measurements, and recording the data.
2. Students rotate through each station learning the instruments and protocols.
3. Reconvene the class. For each measurement:
    a. Plot all the data points as a way of helping students visualize the concept of precision. When measurements are precise, points are close together.

Discuss the range of measurements found and variations among the measurements.

b. Brainstorm with students the issue of discrepancies. This is the time to bring up calibration against standards, reliability, accuracy, and adherence to protocols. Connect explanations with reasons for specific steps in the protocols. Stress the importance of making accurate measurements so they can compare different samples.

c. Compare the results they obtained on samples from various places. Help them make sense of their results by placing data on a map of the water sources and considering the history of each sample in terms of well water, city water, pool, pond, puddle or brook. This is also a good time to stress the importance of accurate measurements when you make comparisons. Is the difference real or measurement error? This is also the time to discuss why we didn't test these samples for DO and temperature and how we might test for them.

ADAPTATIONS

Beginning students
Focus on one measurement at a time, following the outline given above.

Advanced students
Have students create their own data plots and interpret them.

Further Investigations
Repeat the above explorations but vary one parameter – such as temperature by cooling one third of each water sample, and heating one third of the water samples, with the remaining third at room temperature. Then compare the effect of water temperature on the other measurements.

STUDENT ACTIVITY SHEET – TRANSPARENCY STATION

BACKGROUND

Transparency is the measurement of water clarity. How clear the water is at your site will depend on the amount of soil particles suspended in the water and on the amount of algae or other growth at your site. Transparency may change seasonally with changes in growth rates, in response to precipitation runoff, or for other reasons. The clarity of your water determines how much light can penetrate. Since plants require light, transparency becomes an important measurement in determining productivity of your water site.

In the field you would measure transparency in one of two ways; with a Secchi disk in deep, still waters or with a turbidity tube if your site has shallow or running water. For the lab practice station, we will use the turbidity tube.

PROCEDURE

1. Ask each student to fill the turbidity tube with tap water until the image disappears. Record the depth of the water in the tube in cm.
2. Compare data from several students. Ask students to formulate hypotheses on variations in their data.
3. Try the tube again testing variables such as: amount of light in the room, tube in sunlight and shadow, with and without sunglasses, turning the tube to try and detect the image at the bottom, letting the water stand in the tube for 15–20 seconds.
4. Once students have established the depth using tap water, pour the water into a bucket and mix a few grams of silt into the water.
5. Ask students to fill the turbidity tube with the silty water until the image disappears. Record the depth of the water in the tube in cm. Compare the readings from several students.
6. Put a few drops of green food coloring in tap water.
7. Have each student fill the turbidity tube with colored water until the image disappears.

WORK SHEET FOR TRANSPARENCY STATION

STUDENT	SAMPLE TESTED	CM

STUDENT ACTIVITY SHEET – TEMPERATURE STATION

BACKGROUND

Water temperature is the temperature of a body of water such as a stream, river, pond, lake, well, or drainage ditch as it appears in nature. Water bodies can vary greatly in temperature, according to latitude, altitude, time of day, season, depth of water, etc. Water temperature is important because it plays a key role in chemical, biological and physical interactions within a body of water. For example, high temperatures may be an indicator of increased plant production. The temperature of the water determines what aquatic plants and animals may be present since all species have natural limits of tolerance to upper and lower temperatures. Water temperature can therefore help us to understand what may be happening within the water body without directly measuring hundreds of different things within the body of water.

PROCEDURE

1. Following the steps in the *Water Temperature Protocol*, each member of the group should take a turn measuring the temperature of the same sample with the same thermometer. Make sure everyone in the group can read the thermometer. Compare your readings. Are they within 0.5°C of each other? Why? Why not? If not, repeat this exercise with another water sample until you are obtaining readings within 0.5°C of each other.
2. With each member of the team using a different thermometer and following the steps of the water temperature protocol, measure the temperature of a single water sample and compare your readings. Do you get readings within 0.5° C of each other? Why? Why not? If not, your thermometers may need calibration.
3. Following the steps in the water temperature protocol, measure the temperatures of water from the hot and cold water taps, ice water, and the water that has been standing in the bucket.
4. List the things you checked and record the temperatures you obtained for them.
5. Discuss the range of measurements possible with each of the thermometers.
6. Can you take temperatures below the freezing mark? Why? Why not?
7. Can you take the temperature of boiling water with the thermometer provided? Why? Why not?

WORK SHEET FOR TEMPERATURE STATION

STUDENT	SAMPLE TESTED	TEMPERATURE

STUDENT ACTIVITY SHEET – DISSOLVED OXYGEN STATION

BACKGROUND

All living things depend on oxygen to survive. In a water environment the molecules of oxygen gas dissolve in the water. This is called dissolved oxygen (DO). In air, 20 out of every 100 molecules are oxygen. In water, only one to five molecules out of every million molecules are oxygen. This is why dissolved oxygen is measured in parts per million (ppm). Different species of aquatic organisms require different amounts of oxygen, but generally aquatic organisms require at least 6 ppm for normal growth and development.

Water temperature and altitude influence how much oxygen water can hold; i.e., the "equilibrium" value. In general, warmer water cannot hold as much oxygen as colder water. Similarly, at higher altitudes water cannot hold as much oxygen as waters at lower altitudes. Look for these patterns in the Temperature and Altitude Tables in the DO protocol. This is why we use distilled water standard in the protocol and correct for temperature and altitude.

The actual amount of DO in water may be higher or lower than the equilibrium value. Bacteria in the water consume oxygen as they digest decaying plant or animal materials. This can lower the DO levels of the water. In contrast, algae in lakes produce oxygen during photosynthesis, which can sometimes result in higher DO levels in summer.

PROCEDURE

1. Following the steps in the *Dissolved Oxygen Protocol*, each member of the group takes a turn measuring the DO of the same sample. Compare your readings. Are they within 0.2 mg/L of each other? Why? Why not? If not, repeat this exercise with another water sample until you obtain readings within 0.2 mg/L of each other.
2. If your water faucets have aerators on them, test a water sample freshly drawn from the faucet, one that was drawn at the beginning of the day and allowed to sit undisturbed in a bucket, and the preserved sample drawn at the same time. Record the time at which you tested the water in the bucket. How long has it been since the water was drawn? Compare the readings. Are they different? Why? Why not? What might account for the differences?

WORK SHEET FOR DISSOLVED OXYGEN (DO) STATION

STUDENT	SAMPLE TESTED	TIME	DO

STUDENT ACTIVITY SHEET –SALINITY STATION – FOR SALT OR BRACKISH WATER

BACKGROUND

Salinity is the measurement of dissolved salts in salty or brackish water. It is measured in parts per thousand (ppt). Salinity may vary with precipitation, snow melt, or proximity to a freshwater source such as a river mouth.

The hydrometer is an instrument that measures the specific gravity or density of a fluid. Its design is based on the principle, recognized by the Greek mathematician Archimedes that states that the weight loss of a body in a liquid equals the weight of the liquid displaced. The denser your liquid, therefore, the less the weighted bulb must sink to displace its own weight.

Why do you need to take a temperature reading with your hydrometer reading? Water becomes denser as it approaches freezing – then less dense as it becomes ice. Since we want to measure the effect of dissolved salts on density, we must control the temperature variable.

PROCEDURE

1. Fill a 500 mL cylinder with 500mL of freshwater
2. Gently place the hydrometer into the cylinder (do not drop).
3. Read the scale on the hydrometer at the bottom of the meniscus. Record.
4. Remove the hydrometer and add 7.5 grams of salt to the cylinder. Stir.
5. Use a thermometer to measure the temperature in the cylinder 10 cm below the surface. Record.
6. Use the hydrometer to measure the density of the fluid in the cylinder. Record.
7. Look up the salinity of your fluid from the table using the temperature and hydrometer readings. Record.
8. Add 10 grams of salt to your mixture.
9. Measure the temperature and salinity of the fluid. Record.
10. Add a few pieces of ice to the cylinder.
11. Measure the temperature and salinity of the fluid. Record.
12. Examine the data that you have recorded. The salinity of freshwater should be 0. As you add salt to the water, the salinity should increase. Changing the temperature will affect the density of the water, but should not affect the salinity after the conversion is done.
13. Discuss any variations between students. Repeat the measurements if variations exceed 2 ppt.

WORK SHEET FOR SALINITY STATION

SAMPLE	TEMPERATURE	HYDROMETER	SALINITY	STUDENT/S
Freshwater				
7.5 grams salt				
17.5 grams salt				

APPENDIX 2: CONCEPT FRAME

Concept:

Examples:

Characteristics:

What's It Like?

What's It Unlike?

Can You Illustrate It?

Definition:

APPENDIX 3: CONDUCTING LABS – OBSERVATION CHECKLIST

Use the following criteria to assess scientific "habits of mind " (skills, behaviours, attitudes) during labs. During the lab use check marks to indicate occurrences of each criteria. If necessary, this can translated into a score for each student, for each criterion, and as an overall score for the lab activity.

Names	Safe work habits (workspace, handling equipment, etc)	Accuracy & reliability (repeats measurements /experiments)	Works with group members in a cooperative manner	Evidence of perseverance and/or confidence	Comments
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APPENDIX 4: TEACHER/STUDENT LAB RATING SCALE

Experiment Title: _____

Team Members: _____

CRITERIA	POSSIBLE POINTS*	SELF–ASSESSMENT	TEACHER ASSESSMENT
Making a Hypothesis • clearly stated and reasonable			
• includes some justification drawing on prior learning or experiences			
Observing and Recording • evidence of repeated trials is provided			
• detailed data recorded, appropriate units used			
• relevant observations clearly described			
• data are recorded in a clear, well–structured, appropriate format			
Analyzing and Interpreting • graphs are included, where appropriate			
• patterns/trends/discrepancies are identified			
• strengths and weaknesses of approach and potential sources of error are identified			
• changes to the original plan are identified and justified			
Drawing a Conclusion • results are summarized and explained			
• hypothesis is supported or rejected			
• alternative explanations are identified			
• potential applications to or implications for daily life are identified			
TOTAL POINTS:			

**NOTE:* The teacher and/or the class are responsible for assigning the possible points to reflect the particular emphasis of the lab. Students must complete the self–assessment portion of this form and submit it with their written lab report.