



OCEAN ECOSYSTEMS

The Ocean of the World Knows No Boundaries.

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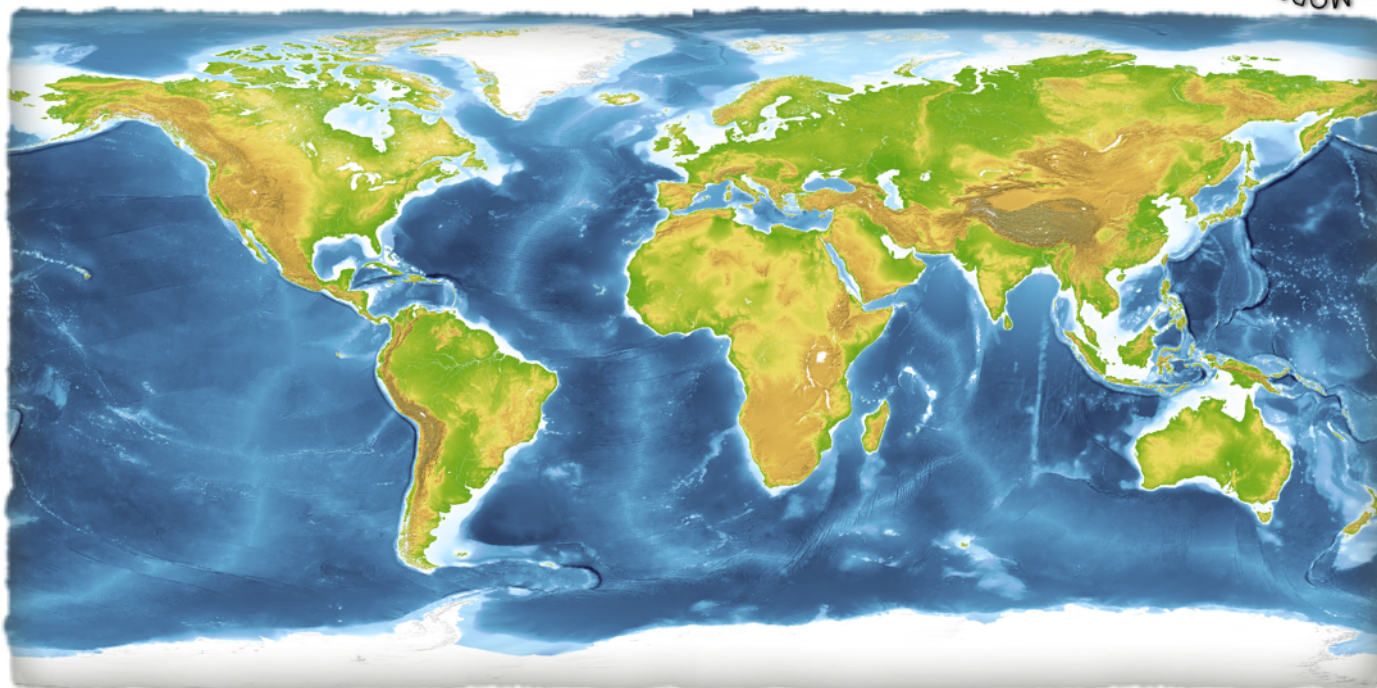
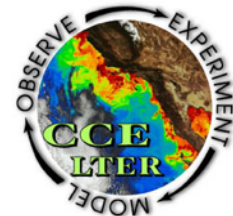


Figure 1: A land and seabed topography map largely derived from satellite radar observations shows in great detail the appearance of the sea floor and the world's major mountain chains, mid-ocean ridges, seamount chains and ocean trenches. The image depicts the features using continuous-tone color and hill-shading. Visualization copyright [Planetary Visions](#) Limited permission, 2011.

What are ocean basins?

There are five major subdivisions on Earth covered by seawater referred to as ocean **basins**; the Pacific, the Atlantic, the Indian, the Arctic and the Antarctic or Southern Ocean. The ocean is in constant motion interacting with the atmosphere transporting heat from the ocean at the equator to the ocean near the poles and then back again. This movement ultimately affects the entire system of interconnected ocean basins and all that exists within it. (See: *Nasa's 'Perpetual Ocean'* visualization).

Many regional geographical features, like those landscapes above sea level, are often mirrored in the ocean basins. These include features like ocean trenches and mountain ranges, canyons and ridges. The largest ocean basin, the Pacific Ocean, stretches from the edges of the continents to the mid-ocean ridges covering approximately 59 million square miles. In comparison, the Southern ocean surrounding Antarctica is 7.8 million square miles.

An incredible variety of life exists within ocean basins and how successful a group of species (**population**) is able to thrive and reproduce is impacted by their geographic range. A species ability to exist over time is constantly influenced by changing **environmental factors** like temperature, salinity, precipitation and nutrients.

Examining the biological and physical impacts of the environment on species as well as the impact of climate on ocean systems have been long standing goals of the [Palmer Long Term Ecological Research \(LTER\) group](#). Scientists in this program have been documenting

changes in seasonal behaviors of species and their shifting ranges since 1990.

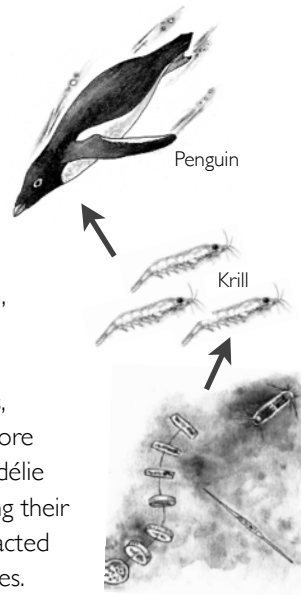
What are ocean ecosystems?

Ocean ecosystems are perhaps the largest, most complex and dominant systems covering nearly 75% of the earth's surface. To investigate ocean ecosystems means that scientists study the system from multiple perspectives. They make connections that are interdisciplinary in nature often considering how the (**biotic**) or living organisms within the system, often ranging in size from microscopic bacteria to large whales, interact with the nonliving (**abiotic**) components like rocks, sand, air and water. Together these components in a system are constantly interacting with each other and with their environment to achieve a balance.

An **ecosystem** in balance accommodates many communities of organisms across large geographic areas. **Communities** of organisms are created when distinct groups or **species** live in the same area. To the surprise of many, Antarctica has one of the most extreme yet productive ecosystems on Earth. While some species in this environment may thrive and find their **niche** near the continental shelf others seem to flourish in the open ocean. Either way, these communities create some of the most diverse marine ecosystems of the world. They also motivate scientists to examine the interactions and relationships between the living (biological), and nonliving (physical and chemical) components as they try to better understand biological relationships, try to monitor change and try to forecast the future.

How does an ecosystem work?

Ocean ecosystems around the world each have unique and distinctive communities of organisms living together and depending on one another for nourishment and shelter. As energy is transferred from a source like plants up through animals, **food chains** are created. The dynamic relationships and connections among the food chains support huge oceanic **food webs** as all animals are linked by what they eat. This transfer of energy from one organism to another creates **trophic levels**. For example, krill (level 2) which is a zooplankton, feed on phytoplankton (level 1) which are algae. Organisms that actively prey on krill (level 3) like Adélie penguins can consume approximately 2 pounds of krill a day during the summer months, especially when they are expending tons of energy foraging offshore finding food for their chicks. In comparison, during the winter Adélie penguins may only eat one third of that when they are not rearing their young. Therefore, the energy demands of the Adélie can be impacted by an ecosystem that may be undergoing dramatic climate changes.



Vocabulary

Abiotic : non living components of an ecosystem.

Atmosphere: air.

Biotic: living components of an ecosystem.

Basins: containing water.

Biosphere: an ecosystem comprising the entire earth and all the living organisms within it.

Communities: groups of species living in the same area.

Ecosystems: the interactions of living organisms and nonliving things in a large physical environment.

Environmental factors: qualities that characterize large bodies of water like temperature, salinity, precipitation and nutrients.

Food Chain: the feeding relationships among a group of organisms in a linear sequence from plants to animals.

Food Web: many food chains connected together.

Inferences: involve logical reasoning and are based on observations and past experiences.

Niche: a range of environmental values in which a species can survive and reproduce.

Optimal Range: the extent to which an organism can thrive and reproduce.

Observations: involves one or more of the senses to find out about an object or event.

Population: all the organisms that both belong to that species and live in the same geographical area.

Species: a group of living organisms that have common characteristics or qualities.

How does climate change impact ecosystems?

All kinds of environmental factors influence a species ability to thrive and reproduce. Therefore, ecosystems are continuously changing as they are impacted by natural physical, chemical and biological processes and cycles. For example, climate change along the western Antarctic peninsula influences the geographic range for species. Climate can influence water temperatures, change precipitation patterns, impact the seasonal timing of sea ice, increase winds, shift nutrients and change cloud cover. Climate drives the timing of many seasonal biological activities for species and these changes shift important ecological interactions. For example, along the western Antarctic Peninsula (WAP) the maximum winter sea ice duration or how long sea ice remains along the (WAP) has become shorter over time. Overall, the WAP region is showing a decreasing trend in sea ice (seasonal) duration with an overall regional decrease as well. This decreasing trend is due to sea ice arriving later in autumn and departing earlier in spring. As a result, many scientists are documenting the impacts of sea ice because it has cascading effects throughout the Antarctic ecosystem.

Instructor overview: The United States has some of the most diverse marine ecosystems of the world. This investigation gives students a chance to explore and compare four different ocean ecosystems. It begins by assigning students to one of four ocean ecosystem illustrations: the Western Antarctic Peninsula, the California Current Ecosystem, the Florida Marine Ecosystem, or the Southeast Alaska Ecosystem. Each illustration is hand crafted by artist and illustrator Kirsten Carlson of the Palmer LTER [Sea Secrets](#) children's book. The illustrations serve to help students make thoughtful observations, to visualize a snapshot of the ecosystem, to compare and to analyze each ocean ecosystem from different locations around the world.

This exercise emphasizes students' ability to read and interpret visual images and representations which is a critical learning skill in understanding new information (Vasquez et. al., 2010). Students begin the activity by familiarizing themselves with the locations of the five ocean basins. They are asked to distinguish and identify several living and nonliving components within the ocean ecosystems. Then, they are asked to compare their observations to an ocean ecosystem that is further away. *Note: Accompanying the ecosystem illustrations are species identification cards. Educators may find that incorporating opportunities to build stacks of similar organisms from each ecosystem may help students demonstrate their understanding.*

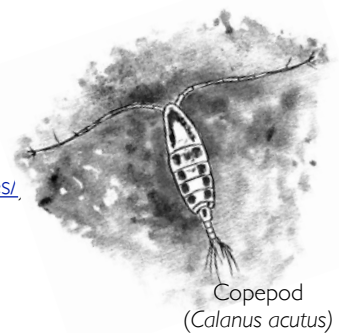
Subject: Biology/Ecology/Marine Science/Oceanography

Time: 45 min. - 1 hour

Grade Level: students grades 3 - 7

Materials:

- * [Ecosystem illustrations](http://pal.lternet.edu/outreach/educators/instructional_materials_resources/) (http://pal.lternet.edu/outreach/educators/instructional_materials_resources/)
- * [Animal Identification cards](http://pal.lternet.edu/outreach/educators/instructional_materials_resources/) (http://pal.lternet.edu/outreach/educators/instructional_materials_resources/)
- * Land and Seabed Map
- * Markers, pencils



Copepod
(*Calanus acutus*)

Objectives:

- Organisms survive in environments in which their needs are met.
- Similar organisms can live in markedly different locations.
- The world has many different ocean ecosystems that support the life of different organisms.
- Biotic and abiotic environmental factors allow all populations of organisms to live together within an ecosystem.
- This activity emphasizes a students' ability to read and interpret visual images and representations

Key Concepts Ocean Literacy Principles:

www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf

The Earth has One Big Ocean with many features:

1a. The Ocean is a dominant feature on the Earth's surface

1b. One Ocean containing five basins

The Ocean supports a Great diversity of Life and ecosystems:

5e. The Ocean is three-dimensional, offering vast living space and diverse habitats from the surface...

5f. Ocean habitats are defined by biotic and abiotic environmental factors...

Climate Literacy Principles:

<http://cleanet.org/clean/literacy/index.html>

Climate change will have consequences for the Earth system and human lives.

7e Ecosystems on land and in the ocean have been and will continue to be disturbed by climate change.

Geography Standards:

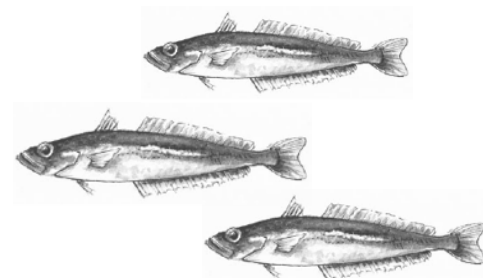
Element 1 Standard 1: The World in Spatial terms: How to use maps...

Element 1 Standard 3: The World in Spatial terms: How to analyze the spatial organization of ...

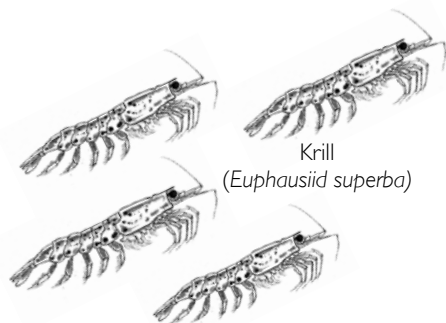
Element 2 Standard 4: Places and Regions: The physical and human characteristics of places

National Science Standards:

- Life Science
 - Organisms and their environment
- Unifying Concepts and Processes
 - Systems, Order and Organization
- Science as Inquiry
 - Abilities necessary to do scientific inquiry
 - Understandings about scientific inquiry
- Personal and Social Perspective
 - Changes in Environment



Antarctic Silverfish
(*Pleuragramma antarcticum*)



Krill
(*Euphausiid superba*)

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Preparation: Print out one set of the Ecosystem illustrations (<http://pal.lternet.edu/education/k-12/instructional-materials-resources>) and the Animal Identification cards. Assign one ecosystem and its animal cards to a group of three to four students. Each group of students should have their own set of worksheets as well.

**Tip: Laminate the species cards and ecosystem illustrations for extended use and have each ecosystem in its own folder.*

Background Before you begin the exercise familiarize students with ocean basins by assigning the background reading. Clarify the meaning of ocean ecosystems and review how ecosystems work. Assess their prior knowledge on the topic of ocean ecosystems and food webs.

Observation Maps: Use the Land and Seabed Map to review with students the location of the ocean basins and all four ecosystem sites that they will be comparing in the exercise.

Observations/Inferences: Younger students may need assistance in completing their, "Investigate a Marine Ecosystem" chart. An *observation* involves one or more of the senses to find out about an object or event. For example, under observations, students can list what they actually see in the illustration. They can be encouraged to use phrases like, "There is a penguin sitting on the ice or there are fish in the water." *Inferences* on the other hand involve logical reasoning and are based on observations and past experiences. On the Antarctic illustration a student response may include, "The leopard seal is probably watching the penguin on the iceberg. However, based on the illustration it is not clear what the leopard seal is watching. Or another example is, "The blue whale appears to be chasing smaller prey."

Check for Understanding: (answers)

1. a. Inference, b. Inference, c. Observation, d. Observation
2. a. Observation, b. Observation, c. Inference, d. Inference

Investigating a Marine Ecosystem: Students will work in their groups to identify and list the abiotic/biotic components of their assigned ecosystem illustration. For example, in the Antarctic illustration...

a. Abiotic components: zodiac, iceberg, air, laboratory building, sand, sun, light, water, oxygen, hydrogen, temperature, detritus, sailboat, rocks, etc.

b. Biotic components: any of the living organisms or plants depicted in the illustrations including humans.

a. Educators might encourage student to consider asking why species are found in particular places? Student answers may vary but should include the principle concept that organisms will preferentially occupy those areas that offer the best set or range of conditions for them to survive, reproduce and build their populations.

b. Why do scientists study environmental factors when investigating a marine ecosystem?

Students should understand that the physical, biological and chemical environmental factors affecting ocean ecosystems are all connected. The environment is both dynamic and diverse. Scientists study these interactions across the ecosystem from a variety of perspectives and disciplines to better understand the complex nature of science and to document how the environmental resources and constraints shape the structure and physiology and success of organisms.

Compare Two Ecosystems: Educators will pair groups of students up to compare ecosystems. Student responses will vary based on which ecosystems the students are comparing. The main objective here is for students to begin to recognize that similar organisms (not necessarily species) can live in markedly different locations under very unique conditions. You may find students considering or documenting animal adaptations, or ecosystem differences. For younger audiences, this question may be best to tackle in an open discussion format.

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Literacy Extension: A children's book called [SeaSecrets: Tiny Clues to a Big Mystery](#) was a collaborative project between Palmer LTER and the California Current Ecosystem LTER. It was written to introduce students grades 3 - 5 on how two ecosystems are experiencing climate change. The story begins with three vignettes about a seabird, a whale and a penguin and then explores further how these animals are being impacted by climate and how researchers are studying these changes. This book serves as a bridge between learning about the basics of ocean ecosystems to understanding relevant concepts and connections to climate change.

Basic Comprehension Questions/Answers for Students reading the book:

- What is at the center of all these changes: *krill*.
- Identify the two ocean ecosystems and the ocean basin where this organism is found in the story.
Western Antarctic Peninsula (Southern Ocean Basin), and the California Current Ecosystem (Pacific Ocean Basin)
- List the two species names for the organisms at the center of this story.
Euphausia superba or Antarctic Krill, *Euphausia pacifica* or the Pacific Krill
- How can two species belong to the same genus yet live so far apart? Students may have a variety of answers. Zooplankton, particularly macrozooplankton, are one of the main trophic links between primary producers and apex predators in the Southern ocean. Euphausiids, more colloquially known as krill, are abundant and encompass over 25% of zooplankton biomass in the world's oceans. They are the foundation species for both the Antarctic ecosystem and California Current ecosystem. They have been shown by LTER scientists to be particularly sensitive indicators of climate forcing including
 - the Pacific Decadal Oscillation - a pattern in the Pacific Ocean north of 20° detected as warm or cool surface waters and
 - El Niño - a warm and cool phases in the atmosphere resulting in patterns of unusual or extreme climate. The two species compared in this story diverge in so many ways that they immediately invite students to learn ecological concepts relevant to ocean ecosystems and to ecological systems in general.
- How can a seabird, a blue whale and an Adèle penguin living very far apart all be connected?
All three charismatic creatures depend upon the same food source within their ecosystem.
- After today's lesson on ocean ecosystems, what could you share with another classmate about what you have learned? Answers may vary.



SeaSecrets children's book by Mary Cerullo and Beth Simmons © 2008.

References:

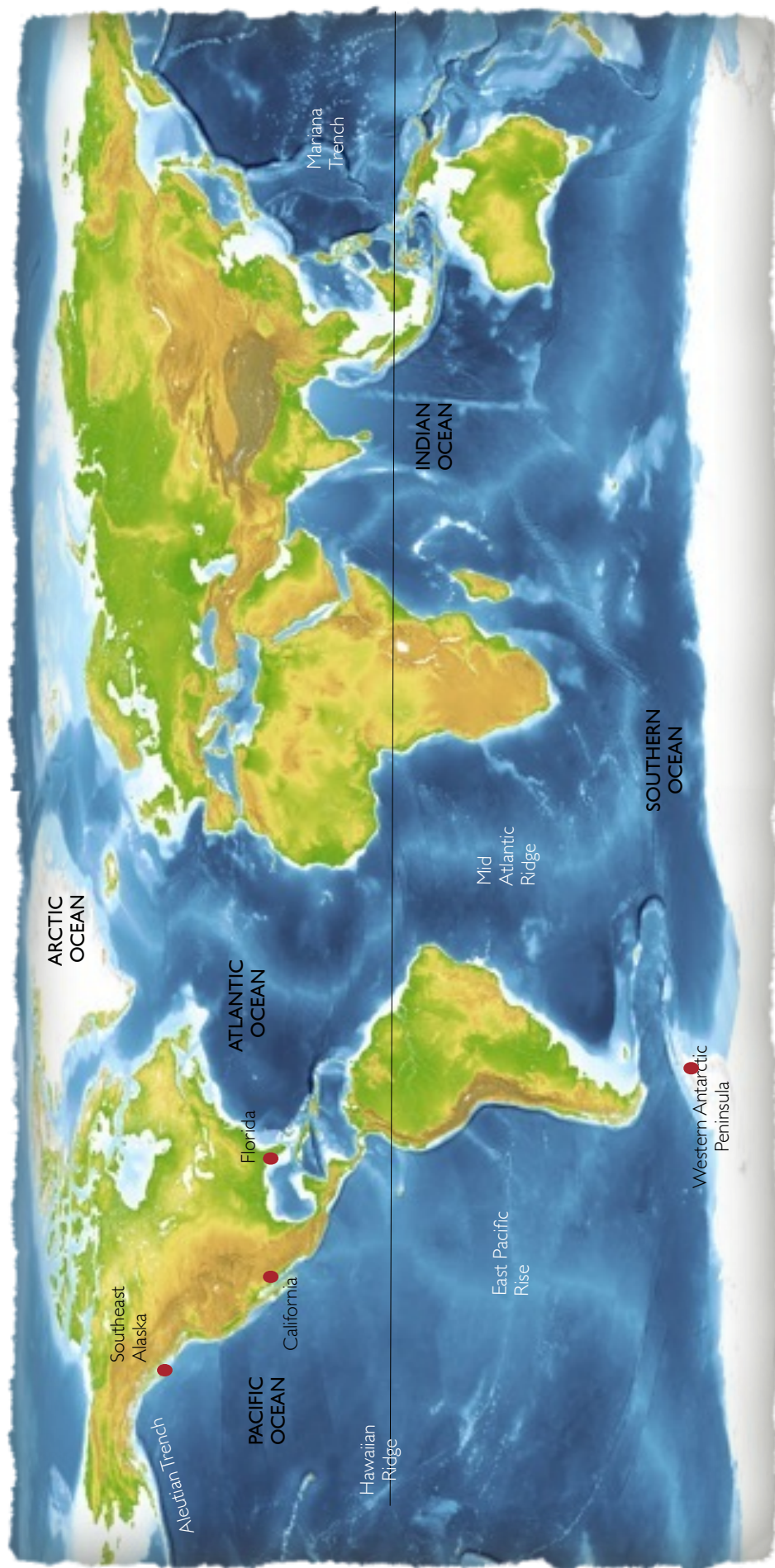
- Vasquez et al., (2010) Developing Visual Literacy in Science K - 8, National Science Teachers Association, pgs. 13 - 20.
- Simmons, B. and M. M. Cerullo (2008) Sea Secrets: Tiny Clues to a Big Mystery, Moonlight Publishing, Layfayette, Colorado. ISBN 10:0-9779603-9-0 pp.32.
- Sherman, K. and Hampel, G. (2009) (Editors) The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya. 2nd printing.
- Steiner A., (2009) (UNEP Executive Director) The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya. 2nd printing.
- Ansberry, Karen R. & Morgan E. (2005) Picture Perfect Science Lessons: Using Children's Books to Guide Inquiry.
- Krebs, Charles (2008) The Ecological World View, University California Press, Los Angeles. pgs. 573.
- Karleskint (1998) Introduction to Marine Biology, Harcourt Brace & Company, pg. 17.

Resources:

- California Current Ecosystem LTER: <http://cce.lternet.edu/outreach/>
- Palmer Station, Antarctica LTER: <http://pal.lternet.edu/outreach/>
- NOAA Ocean Science: http://www.education.noaa.gov/Ocean_and_Coasts/Ocean_Floor_Features.html
- NOAA Ocean Science: <http://oceanservice.noaa.gov/facts/biggestocean.html>
- Ecological Forecasting: http://oceanservice.noaa.gov/education/lessons/dead_zone.html
- The Pacific Ocean Basin: http://www.eoearth.org/article/Pacific_Ocean

LAND AND SEABED MAP

(Planetary Vision, Limited, 2011)

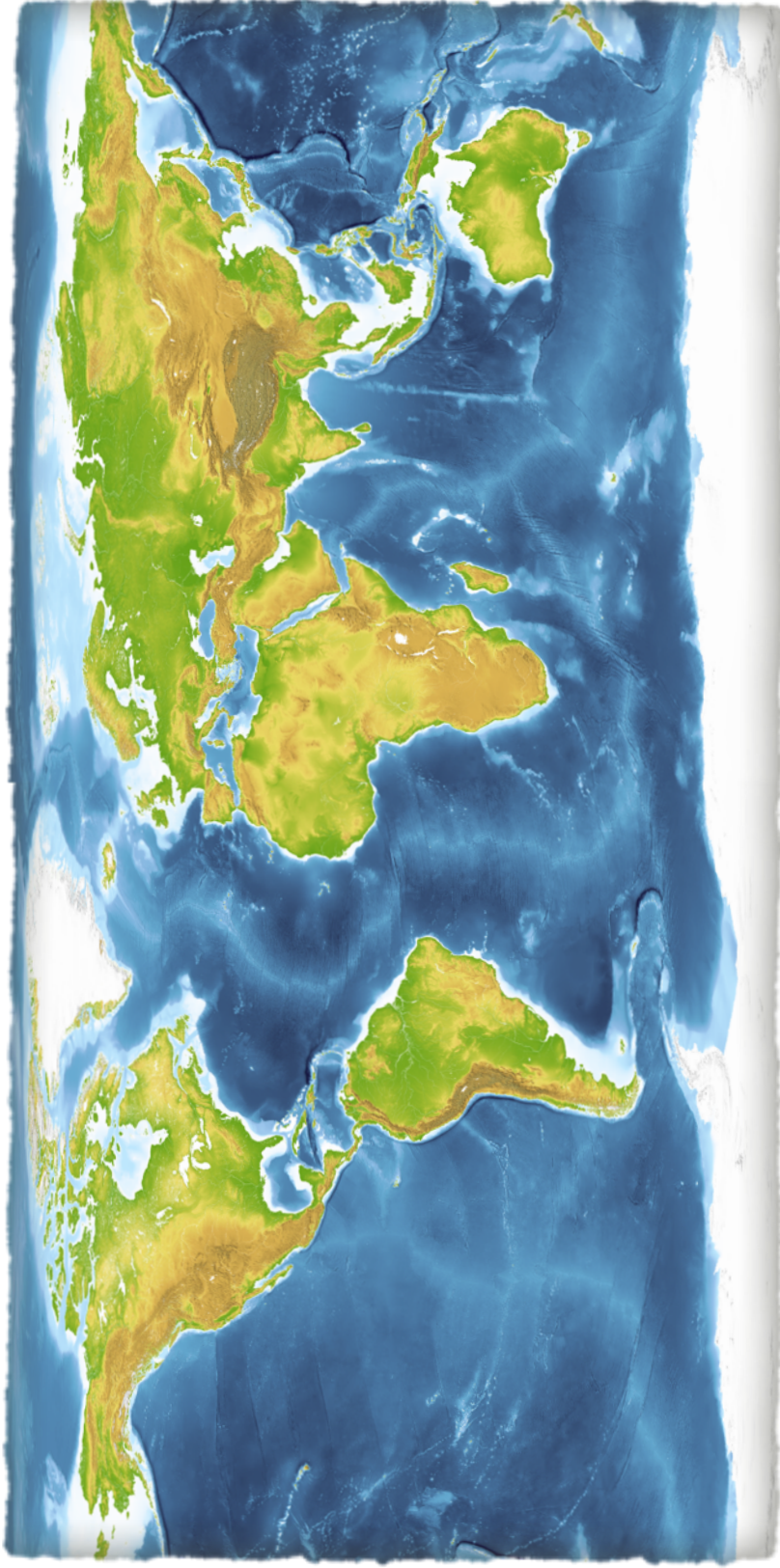


LAND AND SEABED MAP

(Planetary Vision, Limited, 2011)

STUDENT WORKSHEET

NAME: _____ DATE: _____ PERIOD: _____



Observations:

Please take a moment to label the Western Antarctic Peninsula, the Southeast Alaska ecosystem, the California and the Florida marine ecosystems on the map. Then, identify and label which **ocean basin** is nearest each of these locations.

Marine Ecosystem

1. Western Antarctic Peninsula
2. Southeast Alaska Marine Ecosystem
3. California Current Marine Ecosystem
4. Florida Marine Ecosystem

Ocean Basin

STUDENT WORKSHEET

NAME: _____ DATE: _____ PERIOD: _____

Objectives:

- Organisms survive in environments in which their needs are met.
- Similar organisms can live in markedly different locations.
- The world has many different ocean ecosystems that support the life of different organisms.
- Biotic and abiotic environmental factors allow all populations of organisms to live together within an ecosystem.
- The ability to read and interpret visual images and representations; a critical learning skill in understanding new information.

Observations:

Reminder, take a moment to complete your Land and Sea Bed maps.

Observations/Inferences: Investigating a Marine Ecosystem:

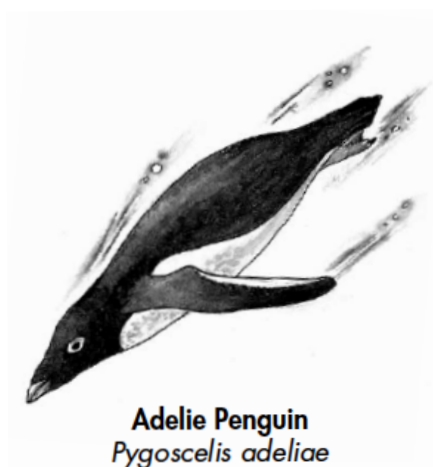
1. One of you will be the lead oceanographer investigating one of the four marine

ecosystems. Among your lab group, write down which marine ecosystem you have been assigned and record it here:

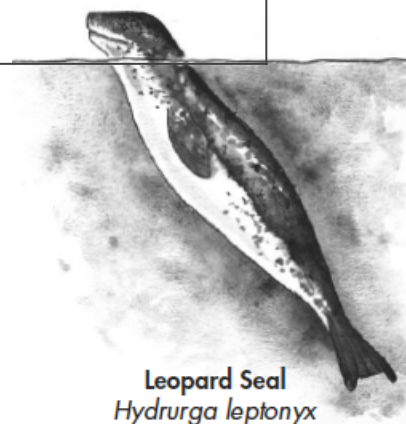
_____. Your instructor will also hand you a folder with your ecosystem illustration and the accompanying animal identification/species cards that correspond to that ecosystem.

2. Modern science today is based on observations and inferences. **Observations** encompass the act of watching something carefully in order to gain information or to find out about an object or an event. **Inferences** involve forming a conclusion based on what you see, hear or know. Inferences are reasonable and insightful.

3. Open your ecosystem folder. Take five - ten minutes to make some general observations and inferences using the illustration that was assigned to you and then fill in the table below.



Observation: (Fact)	Inferences: (Assumptions)
Example: Penguins live in Antarctic. Antarctica is known for its cold temperatures.	Example: Penguins thrive in cold temperatures.
1	1
2	2
3	3
4	4
5	5



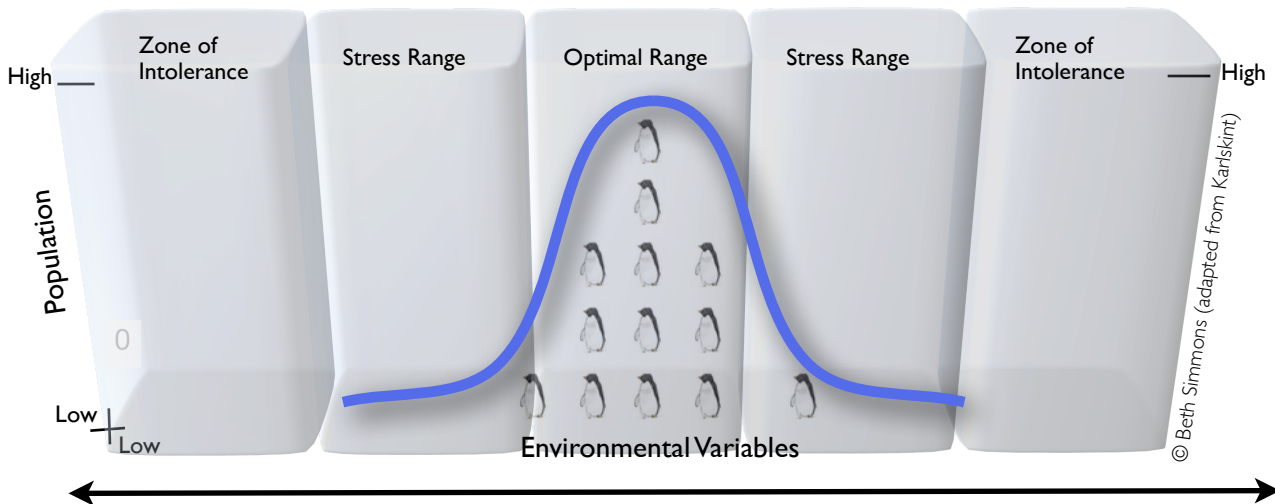
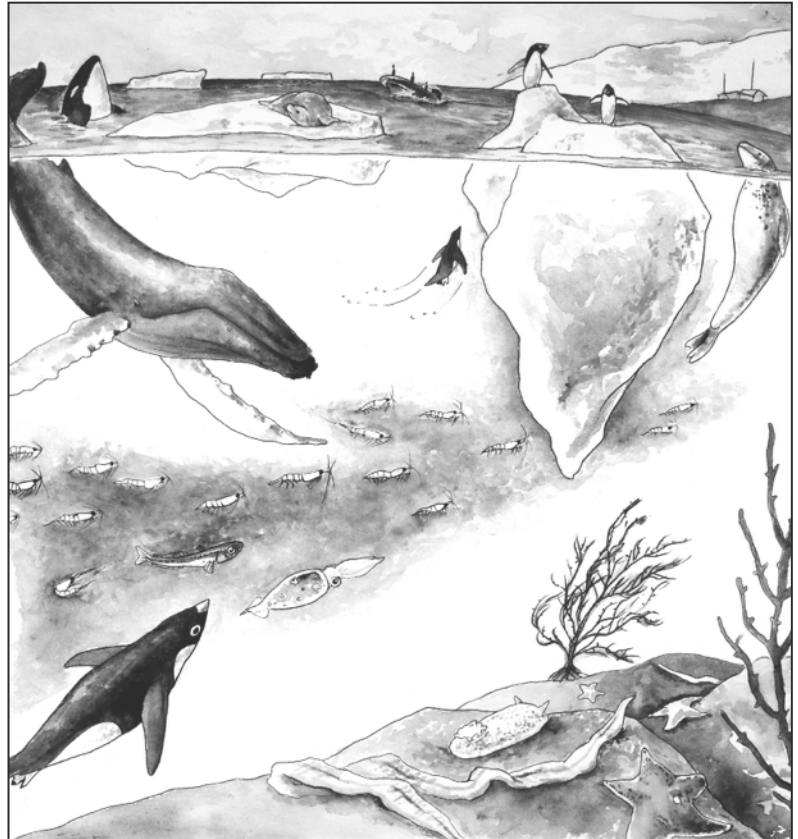
STUDENT WORKSHEET

Check for Understanding:

Objective: Can students differentiate between observations and inferences in science? Examine the graphics and the series of statements about them and then have students determine which statements are classified as observations and which are inferences.

1. A scientist discovers a species of krill below the surface in the Southern Ocean around the western Antarctic peninsula. She makes a sketch of the scene based on her observations and then writes several entries in her journal as a result. Which of the following statements are more likely **observations (O)** and which are more likely to be **inferences (I)**. Label the statements with (I) or (O).

- _____ The whale ingests thousands of krill in every mouthful of water. Krill swim together in swarms.
- _____ Penguin also feed on krill.
- _____ Starfish are bottom dwellers.
- _____ Often times squid and krill are located together.



- _____ As long as the environmental factors remain within the optimal range, Adèle penguins thrive and reproduce.
 - _____ When one or more of the environmental factors is outside the optimal range, Adèle penguins survival rate changes and survival decreases.
 - _____ Adèle penguin populations will avoid living in stressful ranges.
 - _____ Adèle penguins would likely perish in the zone of intolerance.

Answers: 1a. I, 1b. I, 1c. O, 1d. O ; 2a. O, 2b. O, 2c. I, 2d. I

STUDENT WORKSHEET

I. **Investigating a Marine Ecosystem:** Using both the ecosystem illustration and your animal identification cards, identify several non-living (abiotic) and living (biotic) components within your ecosystem illustration. Keep a record of your findings in the chart below.

Abiotic	Biotic
1	1
2	2
3	3
4	4
5	5

a. In an era of global environmental change, why are species found in particular places?

b. Why do scientists study environmental factors when investigating an ecosystem? Write your answer below.

Let's Review:

- Organisms survive in environments in which their needs are met.
- Similar organisms can live in markedly different locations.
- The world has many different ocean ecosystems that support the life of different organisms.
- Biotic and abiotic environmental factors allow all populations of organisms to live together within an ecosystem.

Compare Two Ecosystems:

4. Now as a group, compare two ecosystems and find five (5) similarities or differences?
- Consider similar organisms living in both ocean ecosystems?
 - Consider environmental factors (physical, biological, chemical) affecting the ecosystems?

Factor	Ecosystem A:	Ecosystem B:
Example: Krill	<i>Euphausia superba</i>	<i>Euphausia pacifica</i>
A.	1	1
B.	2	2
C.	3	3
D.	4	4
E.	5	5

References:

1. Vasquez et. al. , (2010) Developing Visual Literacy in Science K - 8, National Science Teachers Association, pgs. 13 - 20.
2. Simmons, B. and M. M. Cerullo (2008) Sea Secrets: Tiny Clues to a Big Mystery, Moonlight Publishing, Layfayette, Colorado. ISBN 10:0-9779603-9-0 pp.32.
3. Sherman, K. and Hampel, G. (2009) (Editors) The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya. 2nd printing.
4. Steiner A., (2009) (UNEP Executive Director) The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya. 2nd printing.
5. Ansberry, Karen R. & Morgan E. (2005) Picture Perfect Science Lessons: Using Children's Books to Guide Inquiry.
6. Krebs, Charles (2008) The Ecological World View, University California Press, Los Angeles. pgs. 573.
7. Karleskint (1998) Introduction to Marine Biology, Harcourt Brace & Company, pg. 17.

Resources:

1. Palmer Station, Antarctica LTER: <http://pal.lternet.edu/outreach/>
2. California Current Ecosystem LTER: <http://cce.lternet.edu/outreach/>
3. NOAA Ocean Science: http://www.education.noaa.gov/Ocean_and_Coasts/Ocean_Floor_Features.html
4. NOAA Ocean Science: <http://oceanservice.noaa.gov/facts/biggestocean.html>
5. Ecological Forecasting: http://oceanservice.noaa.gov/education/lessons/dead_zone.html
6. The Pacific Ocean Basin: http://www.eoearth.org/article/Pacific_Ocean
7. The Southern Ocean Basin: http://www.eoearth.org/article/Southern_Ocean

Optional Literacy Extension:

[Sea Secrets: Tiny Clues to a Big Mystery](#) is a children's book written for 3rd - 5th graders. Its storyline focuses on the research of the Palmer Long Term Ecological research and the California Current Ecosystem LTER, both open ocean research programs. The vignettes at the beginning of the story focus on a seabird, a blue whale and the Adélie penguin and introduce students to the challenges these three organisms are experiencing in their environments. It introduces students to the impacts of climate change on the dynamics within an ecosystem and the organisms that are within those ecosystems.



SeaSecrets children's book by
Mary Cerullo and Beth
Simmons © 2008.

- a. What is at the center of all this change? _____.
- b. Identify the two ocean basins and the two ocean ecosystems where this organism is found in the story.

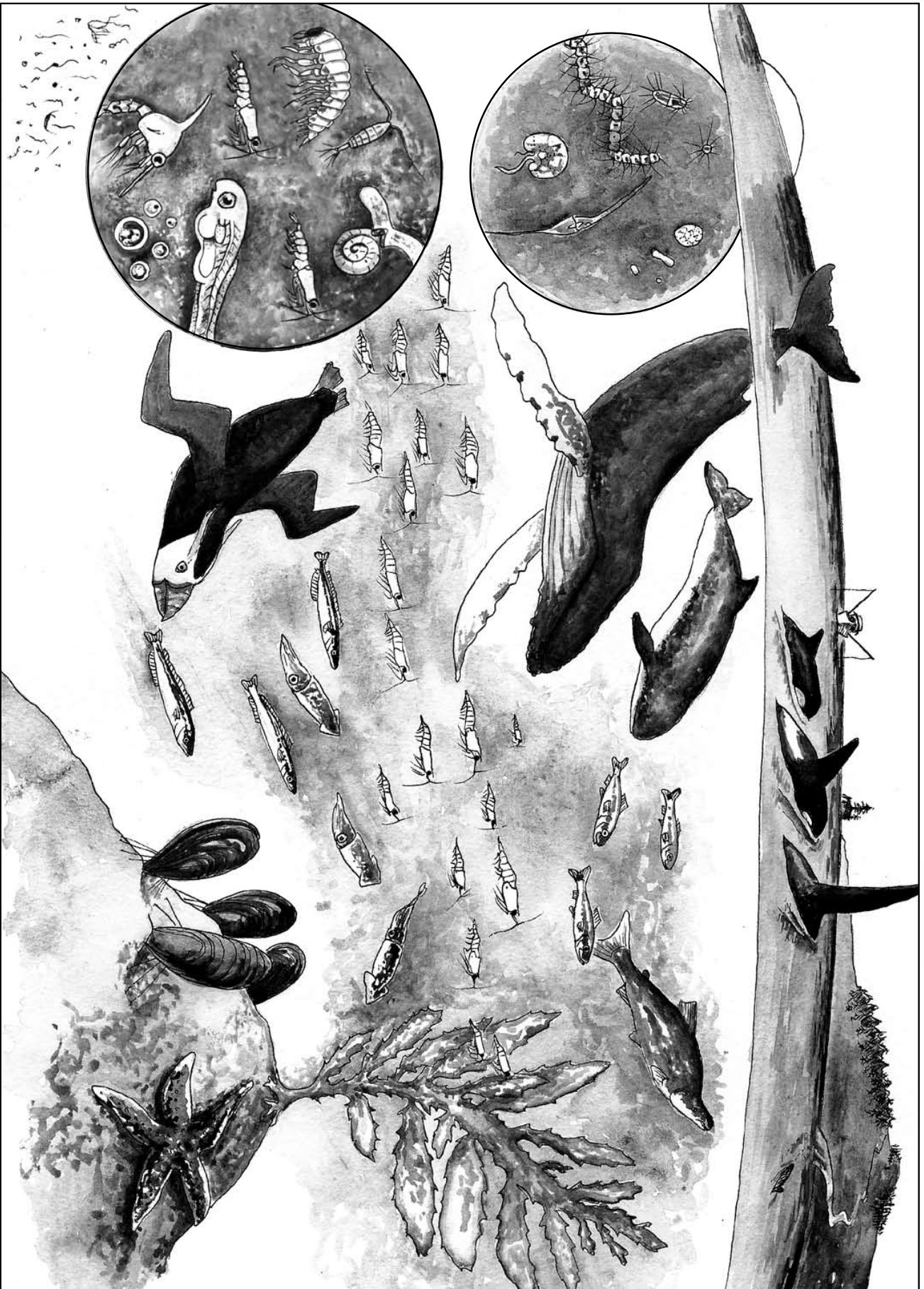
Ocean Basins	Ocean Ecosystems
1	1
2	2

- c. List the two species names for the organism at the center of this story.
 1. _____
 2. _____
- d. How can two species belong to the same *genus* yet live so far apart?
- e. How can a seabird, a blue whale and an Adélie penguin living very far apart all be connected?
- f. After today's lesson on ocean ecosystems what could you share with another student about what you learned?

Western Antarctic Peninsula LTER Marine Ecosystem



Southwest Alaska Marine Ecosystem



California Current ITER Marine Ecosystem



Florida Marine Ecosystem

