The accompanying lessons are dated but still exceptional. Please note that the size of the Aral Sea has continued to shrink considerably more than stated in these lessons. Have students research the current size of the Aral Sea and the Great Lakes and compare their values with those stated in these lessons.

1. Lessons include:
   - Hemispheres The International Outreach Consortium at the University of Texas at Austin - People and Place Curriculum Resources on Human-Environmental Interactions
   - Assessment Evidence
   - Fish or cotton? Role-playing activity in which students take on the roles of citizens whose lives have been affected by the Aral Sea and discuss the impact the changes in the sea level have had on them.

2. For the Common Good
3. Introduction to the Aral Sea reading and comprehension
5. How Great Are the Great Lakes
6. Where Has All the Water Gone?

**Water lessons from National Geographic**
- What Happened to the Aral Sea?
- The Aral Sea Then and Now
- Earth’s Water Cycle

Also included are NASA illustrations showing maps compiled from GRACE data.

**PLEASE NOTE: For the Common Good Activity**

In the introduction the authors say water is a renewable resource. It is very important to note that there is a set amount of water on the planet so it is finite. Because water is recycled indefinitely in the water cycle it has often been thought to be renewable. However human overconsumption and diversion can deplete water from a watershed. This is happening around the world. The Aral Sea is just one example. Saudi Arabia has depleted their groundwater and it won’t be back because it was stored water that has been there for millions of years. Many rivers and lakes around the world have dried up due to overconsumption and diversion. To ensure water will be available for future generations, it is important for people to use it cooperatively and not to sacrifice long-term gain for short-term profits.

These lessons will help your students understand the interrelationships between lakes and rivers. By studying the changes in the Aral Sea, they will understand that:

1. Lakes are affected by both the quantity and quality of water that flows into them from rivers;
2. Damming or diverting rivers, for irrigation and other purposes can have a significant impact on the size and water quality of lakes
3. The negative effects (including environmental, social, economic and health of disappearing natural resources are varied and complex
4. Water is not an infinite resource and must be consumed sustainably
People and Place
Curriculum Resources on Human-Environmental Interactions

Hemispheres is a joint project of:
Teresa Lozano Long Institute of Latin American Studies
Center for Middle Eastern Studies
Center for Russian, East European & Eurasian Studies
South Asia Institute
in the College of Liberal Arts
at The University of Texas at Austin
People and Place
Curriculum Resources on
Human-Environmental Interactions

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TEACHER NOTES

GOALS
This case study will help your students understand the interrelationships between lakes and rivers. By studying the changes in the Aral Sea, they will understand that: (1) lakes are affected by both the quantity and the quality of water that flows into them from rivers; (2) damming or diverting rivers, for irrigation and other purposes, can have a significant impact on the size and water-quality of lakes; (3) the negative effects (including environmental, social, economic, and health) of disappearing natural resources are varied and complex; and (4) water is not an infinite resource and must be managed carefully.

ASSESSMENT EVIDENCE
Fish or cotton?: Role-playing activity in which students take on the roles of citizens whose lives have been affected by the Aral Sea and discuss the impact the changes in the sea level have had on them.

LEARNING ACTIVITIES
• For the Common Good will enable students to understand the concept that consensus and cooperation, rather than individualistic approaches, have better results when using resources.
• With the Introduction to the Aral Sea reading and comprehension worksheet, students will learn the names of the countries that border the Aral Sea, what activities have led to the reduction in water flow into the Aral Sea, and some of the consequences.
• The Disappearing Sea: Maps of the Aral Sea Then and Now shows the changes between 1960 and 2000. For a stronger visual, trace the outlines on transparencies and project the 1960 image, then overlay the 2000 image. Satellite images also show the significant changes in the sea.
• The How Great Are the Great Lakes? graphing activity compares the size of the Aral Sea with that of the Great Lakes. Students can also do research on the size of lakes near their town or city to include in the graph.
• The Where Has All the Water Gone? reading and graphing activity will show students how a decrease of inflow has caused the balance of water in the Aral Sea to change. With the aid of the teacher, students can brainstorm ways in which flow to the Aral Sea could be increased (some options: reduce the amount of land under cultivation, change crop choice to one that requires less water, make sure water used for irrigation isn’t wasted [line canal bottoms so water doesn’t sink into the ground before it gets to the fields, cover canals to limit evaporation], reuse wastewater, etc.).
• The Aral Sea in the News includes excerpts from news articles and commentary about the ways in which the drying up of the Aral Sea has affected local populations who used to depend on the sea for their livelihoods, and various possible solutions to the continuing problem.
• Further Information contains links to other sources of information for further research.
For the Common Good

Introduction:
Renewable resources, such as water, trees, or fish, can be maintained if managed properly. But these resources can be exhausted quickly as the demand for the resources grows. In managing these resources, it is important for people to use them cooperatively and not to sacrifice long-term gain for short-term profits. In the first part of this activity, students play a game where cooperative decisions must be made if all are to benefit. Note: It is best to play the game first without telling the students that the chips represent resources that must be shared.

Materials:
Tokens (such as poker chips or peanuts in the shell)
10 tokens per student should be available altogether
Hard candies, stickers, or something the students value highly
Stopwatch or watch with a second hand
CD or tape player for playing music
CD or tape of lively music
Paper and pencils or pens

Something for Everyone
Procedure:
(1) Count out, but do not distribute, 10 chips for each student playing the game. Put one-fourth of them in a separate pile.
(2) Seat the students in a circle.
(3) In the center of the circle, place the pile comprising one-fourth of all the chips. For example, if you have 10 students, you use 100 chips and begin with 25 in the center.
(4) Read the following rules twice to the students.

Rules:
(1) The chips belong to all of you.
(2) Music will be played, and while it is playing, everybody may take chips out of the pool of chips in the center.
(3) You may trade in 10 chips for a piece of candy (or sticker).
(4) As soon as the music stops, I will double the number of chips left in the pool at that time, and then continue the game.
(5) There will never, however, be more chips in the pool than there are at the start of the game; this is the maximum number of chips the pool can hold.
(6) You may not talk to anyone during the game.

Notes to the Teacher: DO NOT explain the significance of the chips before playing the game. The rules are the only instructions the players get.

The players will most likely empty the pool at the start of the game. Point out that, as it’s impossible to double zero, the game is over. Ask if they’d like to try again. Each student must return all of his/her chips to the pool.
Continue to play the game for several rounds without giving the students time to communicate with one another in between.

When doubling the chips in the pool, remember there can “never be more chips in the pool than at the start of the game.” This is the pool’s carrying capacity for chips.

After several rounds, you may allow the students to talk while the music plays so they can discuss strategies.

After five or six rounds, ask students how they feel about the way the game worked out. As a group, help students think of ways they could cooperate to allow more of them to get their 10 chips without depleting the pool of resources. Play again using the strategies developed by the students.

Discussion Questions:

1. What do the chips represent? (Renewable resources)
2. Can we draw any parallels between the way the group treated the chips and the way individuals and society as a whole use or overuse renewable resources?
3. How many chips were taken out of the pool in the different game variations? How many candies did this generate? How did it make you feel about other members of the group?
4. How did talking about the game make you play differently? After discussing strategies, did it seem that differing attitudes were behind the different ways you played the game? Why did some players take as many chips as they could and others left some behind? How did this make you feel?
5. Have you experienced a similar situation at home, with friends, in your community? (It may help to provide an analogy, such as several people in the house competing for hot water in the morning.) How, in the long run, can more benefit if individuals refrain from taking too much? What sort of attitude do we need to have to achieve the goal of the greatest benefit for all?

Introduction to the Aral Sea

The Aral Sea is more than 5 million years old and was once the fourth largest lake in the world. Fed by two mighty rivers, the Amu Darya and the Syr Darya, it seemed a limitless source of water. Just 40 years ago it was more than 250 miles long and almost 200 miles wide. Since then, the lake has shrunk to 1/3 its original capacity. How could this happen?

In the 1960s, the Soviet Union, of which Kazakhstan and Uzbekistan were a part, decided to increase agriculture in the region. Cotton was chosen as the major crop. The general climate of Central Asia is dry (arid), and it was necessary to irrigate the fields, therefore water was taken from the Amu Darya and the Syr Darya rivers. These rivers begin in the mountains of Kyrgyzstan and Tajikistan and flow through parts of Türkmenistan, Uzbekistan, Karakalpakstan (an independent region of Uzbekistan), and Kazakhstan.

Some experts predicted that diverting water from the rivers would cause the level of the Aral Sea to go down, but others said that it would be a more productive use of water and land to have irrigated fields and a product that could be sold. In fact, cotton production was very successful, and remains one of Uzbekistan’s largest export products. However, the methods of irrigation (including unlined canals and poor drainage) led to water wastage. Overuse of pesticides and fertilizers on the fields polluted the groundwater. Agricultural development led to population increases, as more people were needed to work the fields. More people meant yet more water usage. Between 1960 and 1980, the water flowing into the Aral Sea was reduced by 50%; by now it has been reduced almost 90%.

The current state of the Aral Sea is critical. As less and less water flows into the sea, the level of the sea has dropped, the overall volume has decreased, and the shoreline has receded. Towns that once stood on the coast are now more than 70 kilometers from the sea. Land that used to be under water is now exposed to the air, and wind blows surface minerals for miles. The minerals in the water are more concentrated and salt content (salinity) has increased 400%, killing most fish and wildlife. For decades the major countries affected by the desertification of the Aral Sea and the rivers that flow into it have been discussing ways to better manage water use. Their discussions continue today.
Introduction to the Aral Sea
Comprehension Exercises

(1) What countries surround the Aral Sea? What is the climate of those countries?

(2) What rivers flow into the Aral Sea? Where do the rivers begin?

(3) Why did the Soviet Union redirect water from the rivers that flow into the Aral Sea?

(4) What has happened to the water that remains in the Aral Sea?

(5) What do you think has happened to the fishing industry in towns that border the Aral Sea?
The Disappearing Sea: Maps of the Aral Sea Then and Now

This is one of the earliest maps of the Aral Sea, made by Russian explorers in 1848 and 1849. Note that it is a large sea with a number of small islands.

The Disappearing Sea: Maps of the Aral Sea Then and Now cont.

This map shows the outline of the Aral Sea in 1960 and the outline in 2000. Aralsk and Muinak are towns in which fishing used to be the main industry.

Courtesy of Dr. Siegmar Breckle. Source: German Competence Network for Research to Combat Desertification, http://www.desertnet.de/aralsea.gif

These photographs were taken by satellite in 1989 and 2003. Vozrozhdeniya Island used to be used as a secret military weapons testing base because it was inaccessible and easy to protect.

How Great Are the Great Lakes?

In order to better understand the magnitude of the changes taking place in the Aral Sea, take a look at some large bodies of water here in the United States—the Great Lakes.

The Great Lakes are a series of five lakes in North America that are located in both the United States and Canada. The Great Lakes hold 20% of the world’s fresh water. The Great Lakes, too, are facing challenges in terms of water diversion, although their levels change much less and they are not threatened with destruction. The Great Lakes also have problems such as pollution and invasive species (non-native plants or animals that can change the ecosystem). While each state and country has its own interests in the Great Lakes, many local organizations monitor their status, and the Great Lakes Information Network (GLIN) is a partnership that provides an online resource for people to find information on the Great Lakes–St. Lawrence region of North America.

Source: Great Lakes Information Network, http://www.great-lakes.net/lakes/ (Reprinted with permission.)

Comprehension Exercises

(Look in an atlas for a more detailed map of the Great Lakes with cities indicated.)

1. What countries surround the Great Lakes? Which U.S. states are in the Great Lakes watershed?
2. What challenges and problems do the Great Lakes face?
3. Are the Great Lakes salty or fresh?
4. Where does the water in the Great Lakes come from?
5. Name 5 major cities near the Great Lakes.
6. Look at a map of your state and determine the largest body of water. What relationship does your town or city have with that water (recreation area, reservoir feeder for drinking water, wildlife habitat, etc.)? What is the source of its water supply (underground spring, river, mountain snow runoff)?
7. Brainstorm some businesses that might be associated with that body of water (boat rental, beachside restaurant, ice cream stand, parking lot, nature tour service). What do you think would happen to those businesses if the river dried up or the lakeshore moved farther away?
The Aral Sea and the Great Lakes
Graph Activity

Using the information below, create a bar graph showing the area of the Aral Sea in 1960, the Aral Sea today, and the Great Lakes today.

<table>
<thead>
<tr>
<th></th>
<th>Length (km)</th>
<th>Breadth (km)</th>
<th>Area (sq. km)</th>
<th>Volume (km³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aral Sea 1960</td>
<td>420</td>
<td>280</td>
<td>66,458</td>
<td>1,064</td>
</tr>
<tr>
<td>Lake Superior</td>
<td>563</td>
<td>257</td>
<td>82,100</td>
<td>12,100</td>
</tr>
<tr>
<td>Lake Michigan</td>
<td>494</td>
<td>190</td>
<td>57,800</td>
<td>4,920</td>
</tr>
<tr>
<td>Lake Huron</td>
<td>332</td>
<td>245</td>
<td>59,600</td>
<td>3,540</td>
</tr>
<tr>
<td>Lake Erie</td>
<td>388</td>
<td>92</td>
<td>25,700</td>
<td>484</td>
</tr>
<tr>
<td>Lake Ontario</td>
<td>311</td>
<td>85</td>
<td>18,960</td>
<td>1,640</td>
</tr>
<tr>
<td>Aral Sea 2000</td>
<td>Now two separate basins</td>
<td>23,400</td>
<td>400</td>
<td></td>
</tr>
</tbody>
</table>


Comprehension Exercises
(1) Which lake is the largest? Smallest?
(2) How has the area of the Aral Sea changed in the past 40 years?
(3) What might be the effects on Chicago if Lake Michigan shrank by 75%?
The Aral Sea and the Great Lakes
Graph Activity (cont.)

Area is just one of many ways by which lakes can be compared. Using the information on the previous page, create a graph showing the volume of the lakes. Then answer the questions below.

<table>
<thead>
<tr>
<th>Volume in km³</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,500</td>
</tr>
<tr>
<td>12,000</td>
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<tr>
<td>11,500</td>
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<td>1,500</td>
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<td>1,000</td>
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<tr>
<td>500</td>
</tr>
</tbody>
</table>

|---|-----------|----------|----------|-------|------|---------|-----------|

Comprehension Exercises
(1) List the lakes in order from largest to smallest. Are they in the same order as when you compared them by area?

(2) Why might a lake have a smaller surface area, but a larger volume?

(3) How would a reduction in water volume affect a deep sea? How would it affect a shallow sea?
Where Has All the Water Gone?
The Aral Sea receives water from three sources: the Amu Darya River, the Syr Darya River, and rainfall (precipitation). The sea has no outflow (no rivers which flow out of it), so the only natural water loss comes from evaporation. In 1900 approximately 3 million hectares of land in the area were under cultivation. Before 1960, the level of the Aral Sea was more or less stable. However, in the 1960s when planners decided to increase the area of cotton cultivation, canals were built to redirect water from the rivers and into the fields. As demand for cotton exports increased, more land was used, more water was diverted, and less water flowed into the sea. Between 1960 and 1980, more than 4 million additional hectares of land were put under cultivation, essentially doubling the irrigated territory and the amount of water taken out of the rivers. One of the longest irrigation canals is the Karakum Canal, which goes from the Amu Darya towards the west about 1300 km, into the Karakum Desert.

Look at the table below and create a line graph showing the decrease of inflow into the Aral Sea from 1926–1985.

<table>
<thead>
<tr>
<th>Period</th>
<th>River inflow (km³)</th>
<th>Precipitation (km³)</th>
<th>Total inflow (km³)</th>
<th>Evaporation loss (km³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1926-1960</td>
<td>55.2</td>
<td>8.2</td>
<td>63.4</td>
<td>64.1</td>
</tr>
<tr>
<td>1960-1970</td>
<td>42.8</td>
<td>8.4</td>
<td>51.2</td>
<td>63.3</td>
</tr>
<tr>
<td>1970-1985</td>
<td>16.3</td>
<td>6.6</td>
<td>22.9</td>
<td>56.2</td>
</tr>
</tbody>
</table>


Comprehension Exercises
1. How much annual inflow (km³) is needed to keep the level of the Aral Sea from shrinking any further?

2. Brainstorm ways that inflow can be increased.
The Aral Sea in the News

Reading 1

“In arid areas, water is an invaluable gift of nature. All of life depends on water—life comes to a halt where water has vanished. And water resources in Central Asia are extremely limited. It is not surprising that nowadays all the water resources of the Aral Sea basin region […] are fully consumed by the national economies. Because the watershed for the region is mostly located in the mountains of Kyrgyzstan and Tajikistan, and most of the water resources are used for irrigation by the Central Asian republics, it is necessary to have joint and coordinated management of the limited water resources of the entire Aral Sea basin region in the interests of all the states of the region. This management must also meet ecological requirements to provide water to the rivers’ delta and to the Aral Sea itself.”


Reading 2: Kazakh fishing port haunted by ghost of dying sea

ARALSK - Aralsk is the town that time forgot. Dilapidated factories stand silent and crumbling. Rusty cranes loom over a bleak landscape, which is littered with fragments of broken and abandoned machinery.

Its port, once the pride and joy of its residents, is dry and empty. No fish, cargoes or boats come through here anymore. Fishermen are an endangered species. It is only the eerie, rusting hulks of ships and the salt-encrusted earth that are testament to a sea that once lapped at the very edges of the town.

People in Aralsk say it has been more than 25 years since they could see the Aral Sea, and now the once-thriving port resembles nothing more than a huge, rubbish-strewn sand pit.

Enquiries as to the whereabouts of the water are treated like a bad joke. “The sea? What sea? We don’t have a sea here anymore,” said a man disembarking at Aralsk’s train station. Behind him a huge mural shows how the people of Aralsk provided fish for a hungry nation on Bolshevik leader Vladimir Lenin’s request.

The Aral Sea, which straddles the former Soviet Central Asian republics of Uzbekistan and Kazakhstan, is dying. And the former fishing port of Aralsk is fading along with it.

The water-thirsty region has two great rivers, the Syr Darya and the Amu Darya, which used to feed the Aral Sea. But in the 1960s Soviet planners built a network of irrigation canals to divert their waters into cotton fields in Uzbekistan and Turkmenistan, starving the sea of its life blood. Now a mere trickle reaches the sea, and the water that does is contaminated by the residues of pesticides, fertilisers and defoliants used on the cotton fields.

Dying Sea Bleeds Town Dry

Once the world’s fourth largest lake, the Aral has shrunk so much that it has now split into two separate bodies of water—the northern or ‘little Aral Sea’ and a larger southern body.
“We didn’t realise what was happening at first,” said local resident Gulzhikhan Abdulgaziyeva. As a clanging metallic noise echoed across the port-turned-dust bowl, she sighed and said: “That used to be a repair shop for barges and boats. Now they only fix cars.”

It is not only the fishing and shipping industries that have suffered from the sea’s disappearance. Textile and electronics factories lie empty and the town mill does not work anymore. Desertification and high salt levels are damaging agriculture.

The town of Aralsk is home to around 39,000 people and the Aralsk region around 68,000. It has one of the highest unemployment levels in Kazakhstan. “We have lots and lots of unemployment here. I myself sat for three years without work,” Gulzhikhan said. She now does some work at the town’s tiny, private guest house. “But we have very few entrepreneurs like (the hotel boss). If we had more maybe we would have less unemployment.”

**Health Problems**
The United Nations Development Programme (UNDP) has been running an Aral Sea Programme since 1995. It focuses mainly on water resources management, small business development, humanitarian assistance and a social and health programme.

For the ecological disaster of the dying sea has brought climate change—colder winters and hotter summers—to the region and a host of associated health problems. UNDP says anaemia in women, tuberculosis and high infant mortality are among the major health issues. Incidences of cancer and respiratory diseases have also risen.

“We have lots of health problems now because of the ecological situation...deformed kids are born,” Gulzhikhan said.

And everyone you meet in Aralsk warns of rising crime blamed on unemployment.

Aralsk’s museum is like an obituary to the town’s former livelihood. Curator Rysbek Akimov proudly shows off the seashell fossils and fish teeth stacked in glass cases and enormous pickled fish stare out of jars.

“Once upon a time people all over the Soviet Union bought our fish. They were very tasty fish even though it was a small sea,” he said wistfully.

Sergei Sokolov, UNDP national project manager in Aralsk, says it is now around 90 kilometres (55 miles) from Aralsk to the sea.

By Tara FitzGerald, 4/9/2002.
Reading 3: Aral Sea poison dust danger

Researchers have discovered that contaminated dust from the Aral Sea has blown hundreds of kilometres across Central Asia, raising new concerns about the consequences for human health. The study, by a team from the UK, found that some of the highest deposits from the old Aral seabed are in southern Turkmenistan, far away from the epicentre of what’s been described as the world’s worst man-made environmental disaster.

The researchers from Nottingham University say the devastating impact on human health needs to be urgently assessed.

For years now, people living around the Aral Sea have been suffering from the toxic cocktail of pesticides and salts that blow off the old seabed.

The Aral used to be the fourth largest inland sea in the world, but the Soviets siphoned off the waters that feed it to irrigate the vast cotton fields of Central Asia. As a result, the Aral Sea shrank by almost half, leaving a toxic wasteland that has blighted the land and its people.

For the first time, this new study shows just how wide the area is of those affected by the polluted dust that now blows off the old seabed—and how deadly are the pesticides and salts they carry.

Health concerns

The researchers collected dust samples from as far away as Turkmenistan’s border with Afghanistan, hundreds of kilometres to the south. And worryingly, it was in the areas furthest away that they found the highest concentrations of dust.

Ian Small, the director of Medecins Sans Frontieres in Uzbekistan, said: “The region has one of the highest rates of acute respiratory infections in the world. It’s estimated that, if and when the sea completely dries up, there will be 15 billion tonnes of salt liberated into the environment. So clearly, the problem is getting worse and we need to determine what is the human health effect.”

Already it has been suggested that the toxic dust from the Aral has been carried as far as the Himalayas and Belarus.

There are also concerns that the high salt content is contributing to the melting of glaciers high in the Pamir Mountains, where Central Asia meets Afghanistan and from where the rivers that feed the Aral Sea flow.

By Central Asia Correspondent Louise Hidalgo, 2/18/2000.
The Aral Sea in the News
Comprehension Exercises

(1) What was the main industry of the town of Aralsk 25 years ago? What is the main industry today?

(2) How have citizens in Aralsk adapted to the changes brought about by the shrinking of the sea?

(3) What sort of health problems are people facing in the region?

(4) How many countries are affected by the changes in the Aral Sea?

(5) Why are international organizations interested in working in the area?
Fish or Cotton? Role-Playing Activity

Divide the class into 4 groups and assign each group one of the following cards. Have the students discuss their point of view within their groups and then prepare a statement regarding the importance of their situation to present to the class.

Role-Playing Cards

---

You are an Uzbek government official.

The export of cotton is very important to your country. Higher exports bring in more money, which means a higher standard of living for your citizens. Irrigation of the cotton fields is essential in order to keep up your production levels.

---

You are a citizen living in Aralsk.

Your family used to be fishermen, but your town is now 60 miles from the sea. You’ve worked at odd jobs, but haven’t had a good-paying job in 5 years. You’ve heard that the Caspian Sea is rising—why not redirect that water to the Aral so the sea could be restocked with fish?

---

You are a doctor in Karakalpakstan.

In recent years you’ve seen more and more cases of anemia, cancer, and respiratory infections. You suspect the toxic dust blowing from the seabed is causing the problems.

---

You are a cotton farmer in Kazakhstan.

The soil in your field is not very good, and to ensure a good crop of cotton, you need to enrich it with fertilizer. Your family depends on the cotton crop for its livelihood.
Further Information on the Aral Sea

LakeNet is a global network of people and organizations in more than 90 countries dedicated to the conservation and sustainable development of lake ecosystems: http://www.worldlakes.org/lakedetails.asp?lakeid=9219

The Water Page is an independent initiative dedicated to the promotion of sustainable water resources management and use: http://www.thewaterpage.com/aral.htm

The Web site of Environmental Health Perspectives (EHP) is a peer-reviewed open access journal dedicated to the effect of the environment on human health. EHP is a publication of the Public Health Service, U.S. Department of Health and Human Services, National Institutes of Health, and National Institute of Environmental Health Sciences (NIEHS): http://ehp.niehs.nih.gov/members/2001/109p547-549small/small-full.html

AQUASTAT is a global information system on water and agriculture developed by the Land and Water Development Division of FAO (Food and Agriculture Organization of the United Nations). The objective of AQUASTAT is to provide users with comprehensive information on the state of agricultural water management across the world, with emphasis on developing countries and countries in transition: http://www.fao.org/waicent/FaoInfo/Agricult/AGL/AGLW/aquastat/regions/fusst/index8.stm

More information on the Great Lakes can be found through the Great Lakes Information Network: http://www.great-lakes.net/

Satellite images of the Aral Sea. The purpose of NASA's Earth Observatory is to provide a freely-accessible publication on the Internet where the public can obtain new satellite imagery and scientific information about our home planet. The focus is on Earth's climate and environmental change: http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=16277
About Hemispheres

Created in 1996, Hemispheres is the international outreach consortium at the University of Texas at Austin. Hemispheres utilizes University resources to promote and assist with world studies education for K-12 and postsecondary schools, businesses, civic and non-profit organizations, the media, governmental agencies, and the general public.

Comprised of UT’s four federally funded National Resource Centers (NRCs) dedicated to the study and teaching of Latin America; the Middle East; Russia, East Europe & Eurasia; and South Asia, Hemispheres offers a variety of free and low-cost services to these groups and more. Each center coordinates its own outreach programming, including management of its lending library, speakers bureau, public lectures, and conferences, all of which are reinforced by collaborative promotion of our resources to an ever-widening audience in the educational community and beyond.

Hemispheres fulfills its mission through: coordination of pre-service and in-service training and resource workshops for educators; promotion of outreach resources and activities via exhibits and presentations at appropriate state- and nation-wide educator conferences; participation in public outreach events as organized by the consortium as well as by other organizations; and consultation on appropriate methods for implementing world studies content in school, business, and community initiatives.

For more information, visit the Hemispheres Web site at:
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Water lessons from National Geographic

Key Concepts

1. seas
2. ocean
3. Sea Levels
4. climate change
5. Aral Sea
6. region

What happened to the Aral Sea

Your Mission
The Aral Sea is in trouble, as are the people who live nearby. Help figure out why people in the Aral Sea region have so many complaints.

Briefing
The Aral Sea, located in the former Soviet Union (today's Kazakhstan and Uzbekistan) has shrunk by more than 60% in over 30 years! Look at these satellite images of the sea to see how much it has changed.

What happened to the Aral Sea? The Aral Sea region is big cotton farming country. The Amu Darya and Syr Darya rivers flow through cotton farmland into the sea. In the 1950s, the Soviet government decided to divert some of the water from these rivers to irrigate the cotton fields. As more water was diverted for agriculture, less and less river water flowed into the sea.

Changes to one part of a region often lead to other changes. Here are some of the results of the shrinking of the Aral Sea:

- As water has been drained from the rivers for cotton farming, the sea's water has become much saltier.
- As more water has been taken from the rivers, the sea's water level has decreased by over 60%.
- Drinking water supplies have dwindled, and the water is contaminated with pesticides and other agricultural chemicals as well as bacteria and viruses.
- The farms in the area use some highly toxic pesticides and other harmful chemicals. For decades, these chemicals have been deposited into the Aral Sea. When the wind blows across the dried-up sea, it carries dust containing these toxic chemicals.
- Lakes and seas tend to have a moderating effect on the climate. In other words, the land right next to a body of water tends to be warmer in the winter and cooler in the summer than land that's not near the water. As the Aral Sea has lost water, the climate has become more extreme.

What would it be like to live near the Aral Sea? Below are some things the local people might say about their experiences since the sea began to shrink. Read the quotes, and match them up with the causes above. Each quote can be matched to more than one cause. When you're finished, you will be able to help the people of the Aral Sea region figure out why they are having so many problems.

"I live in the town of Nukus. My father and grandfather were fishermen in this town, but as you can see, the boats are now sitting in the middle of a desert."

"I am 30 years old. Last year, I started having trouble breathing, and I always have a bad
cough. I live 20 miles downwind of the Aral Sea."

"I am a fisherman, but these days there's not much money in fishing. The fish who used to live in the Aral Sea don't seem to like the water conditions any more, and they're dying out quickly. Perhaps we should reintroduce some saltwater fish into the sea."

"I can't believe I have to wear so many layers of clothes these days! I guess I'll have to knit a new sweater, if I can get some wool."

"I am a doctor in the town of Muynak. In the past decade, I've treated many people with throat cancer, diseases caused by microorganisms, and other serious conditions."

FAMILY FILES

Younger Xpeditioners: Think of a lake or another body of water near your home. What do you think would happen if the water level started to go down? How might it affect people, animals, and plants? In what ways might your town or region look different?

Older Xpeditioners: Imagine you have been sent to the Aral Sea as a specialist to help solve the problems there. Describe the major problems you would be tackling, and brainstorm the things you could suggest to help the situation.

Parents: Discuss with your children the problem of water scarcity. Is water plentiful in your region or are there water-related conservation issues? Explain that, since water is essential for life but is not abundant everywhere, people sometimes argue or even fight over rights to water. For example, the dry western states are currently trying to figure out how they are going to provide water for all the new people who are moving there. Also discuss the importance of having a clean drinking water supply. Inform your children or work with them to find out where your local drinking water comes from. Then help them brainstorm ways that they and other people in the community can help keep the water supply safe and clean.
Lesson 2 -
The Aral Sea - Then and Now

Key Concepts

1. Evaporated Sea
2. evaporation
3. Salt Deposit
4. Aral Sea Region
5. Saltwater
6. water
7. Physical Environment
8. Environmental Issue
9. Aral Sea
10. Inland Sea
11. Shrinking Sea

Grades 3-5

Overview:
The shrinking of Asia's Aral Sea has led to a number of problems for people in the region. This lesson asks students to consider what happens when a sea shrinks and to compare pictures of the Aral Sea at different times. They will conclude by pretending to be residents of the Aral Sea region, drawing "before" and "after" pictures of how changes to the sea have affected their lives.

Connections to the Curriculum:
Geography, earth science, environmental studies

Connections to the National Geography Standards:
Standard 14: "How human actions modify the physical environment"
Standard 15: "How physical systems affect human systems"

Time:
Two hours (not including observing the evaporation experiment for one week)

Materials Required:
- Computer with Internet access
- Wall map of the world
- Measuring cups
- Measuring spoons
- Salt
- Shallow bowls (preferably colored ones so students can observe salt after water evaporates)

Objectives:
Students will
- conduct an experiment to see whether salt evaporates with water;
- hypothesize what might happen to people, animals, and plants living near a shrinking sea;
- compare satellite images of the Aral Sea from 1973 and 1999;
- do the Aral Sea family activity, matching problems in the Aral Sea region with people's statements about these problems;
- discuss changes that are occurring in the Aral Sea region; and
- draw pictures depicting the lives of people in the Aral Sea region before and after the sea began to shrink.

Geographic Skills:
Acquiring Geographic Information
Organizing Geographic Information
Analyzing Geographic Information

Suggested Procedure
Opening:
Begin the lesson by conducting a simple evaporation experiment. Have students place two tablespoons (30 ml) of salt into a measuring cup and then add warm water until the water level is at one cup (240 ml). They should stir until the salt is completely dissolved. Have them pour the mixture into a shallow bowl, and ask them to imagine that they have created an inland sea. [Note: Real seas do not have nearly this much salt in relation to water, but the exaggeration in this
experiment will help students see the results more clearly.
Have students place their "seas" near a window, if possible, and look at the water level every day for one week. Ask them to record the changes to the water's appearance.

Development:
Ask students what their experiments show might occur if the water level in a real sea were to gradually drop. They should understand that the salt doesn't evaporate with the water. Some of the salt is deposited on the ground around the perimeter of the evaporated sea, some settles on the bottom, and much remains in the water.
Ask students to explain what they think might happen to people, animals, and plants that depend on a sea that is shrinking. How would a reduction of the water level affect people's ability to drink, bathe, and irrigate their farms? How would people, animals, and plants like the saltier water?

Introduce students to the Aral Sea by pointing out its location on a world map (between Kazakhstan and Uzbekistan in the former Soviet Union). Explain that the Aral Sea has shrunk by more than 60 percent in over 30 years because water flowing into the sea has been diverted for cotton farming. As residents there have discovered, when salt water is removed from its original area (through evaporation or diversion), it leaves salty deposits and the water itself becomes more salty.

Have students look at satellite images of the Aral Sea. Ask them to view the images for 1973 and 1999, making sure they view from the six-mile range (the small box on the lower left will say "24 mi"). Ask them to compare what they see in the two images and answer these questions:

- Looking at the 1973 photo, imagine that this part of the sea looks like a dog (with ears at the top and an upraised paw). What has happened to the "dog's" head in the 1999 photo? Why would this have happened?
- What other things do you notice in the 1999 image to suggest that the sea has become smaller?

Have students complete the Aral Sea activity and read the briefing information to learn more about how the Aral Sea has changed and how it affects the people who live near it. They should record their answers to the matching activity on their own paper. Before they go through this activity, point out that increased salinity is just one of the problems the Aral Sea is facing; they will see this as they do the activity.

Closing:
Discuss students' answers to the matching activity on the Aral Sea activity. Then review what students have learned by discussing the following questions:

- Why has the water become more and more salty?
- Why are more people getting sick?
- How is the climate changing?
- What has happened to the fishing industry, and why?

Suggested Student Assessment:
Ask students to pretend that they are older and have lived near the Aral Sea for at least 30 years. Have them draw two pictures—one depicting their lives before water was diverted from the sea, and the other showing what their lives are like today.
Have students look at their drawings and consider the things they have learned in this lesson. Ask them to write paragraphs answering the question "What are some of the reasons that it's a good idea to take care of seas, lakes, and rivers?"
Extending the Lesson:
Ask students to imagine that a body of water near them, such as a lake or river, is shrinking. Have them script and stage a play portraying what people in their community might say and do about this situation. Their characters can include schoolchildren, parents, local politicians, local businesspeople, animals (or people who work to protect animals), and other individuals who might be affected by this situation.

Related Links:
http://earthshots.usgs.gov/Aral/Aral
The Water Cycle at Work - Lesson on ground and surface water EPA

Lesson 3 - Earth’s water cycle

Key Concepts

1. water cycle
2. ocean
3. precipitation
4. evaporation
5. condensation

• Directions
• Objectives
• Preparation
• Background & Vocabulary

What You’ll Need

Materials You Provide

• Chart paper
• Markers
• Pencils
• Transparent tape
• Writing paper

The resources are also available at the top of the page.

Images

• Water Cycle

Interactives

• National Geographic Education: MapMaker Interactive

Maps

• NG MapMaker Interactive: Population Density—World

Required Technology

• Internet Access: Required
• Tech Setup: 1 computer per classroom, Projector

Physical Space

• Classroom

Grouping

• Large-group instruction

Directions

Tips & Modifications

1 of 1

Modification

Pre-teach some of the vocabulary—including evaporation, condensation, and precipitation—to help students, especially English language learners, identify words, place them in context, and remember them.

1. Discuss how much water the ocean contains.
Display the MapMaker Interactive and make sure students can all identify which areas are land and which are ocean. Ask: *Does the Earth have more land, or more ocean?* Students should notice that there is more ocean than land. Explain that the ocean covers almost three-quarters of Earth’s surface and is very deep. It contains almost all the water on Earth—about 97%. That’s a lot of water!

### 2. Introduce the water cycle.

Ask: *Do you think all that water stays in the ocean? Where do you think rain comes from?* After students share their ideas, explain that they are going to draw an illustration that shows how Earth’s water is always on the move in a kind of circle called the water cycle.

### 3. Have the class draw the water cycle as they learn about its three stages.

Tape a large sheet of chart paper to the board. Have one student use a marker to draw the ocean. Have another student draw the sun shining above.

- **Stage 1: Evaporation**—Explain that the sun heating up the ocean causes tiny drops of water to rise into the air and turn from a liquid into a gas called water vapor. This process is called evaporation. Have a student illustrate this, draw an arrow representing water evaporating, and label it.

- **Stage 2: Condensation**—Explain that as water vapor rises higher, the air gets cooler. This causes the gas to turn back into water drops, which form clouds. Have a student draw a cloud over the ocean. Explain that this process is called condensation, and add that label.

- **Stage 3: Precipitation**—Ask: *Do clouds stay in one place?* When students answer no, explain that clouds move with the winds. Have one student draw an area next to the ocean representing land, and have another draw an arrow showing the cloud moving over the land. Explain that as the water drops in clouds get cooler and heavier, they fall to Earth as rain—or, if it’s very cold, as sleet, hail, or snow. Explain that this is called precipitation and add that label. Have students draw different forms of precipitation falling from the cloud.

Discuss what happens to rain and snow on Earth. Most falls back into the ocean. Some falls into rivers that flow into the ocean. Some falls on land, sinks into the ground, and drains slowly back into the ocean. It may take thousands of years, but eventually all water returns to the ocean. Have students draw a river emptying into the ocean and water sinking underground and draining into the ocean. Tell students their illustration of the water cycle is now complete. Project the USGS water cycle diagram and have the class compare the two and add additional details to their illustration, if needed.

### 4. Ask students to make connections to their location.

Have students personalize the water cycle by connecting it to where they live. Project the provided MapMaker Interactive: World—Population Density. Zoom in on your city or town. Slowly zoom out and have students look for nearby mountains, lakes, and rivers. Have students explain how these features connect to the nearest ocean. Point out to students how most large cities are located near sources of water, and explain that humans have historically settled near water sources.
5. Have students work independently to each write a story about one water drop’s journey.
Tell students that they are now going to write a story about the experiences of one water drop as it travels through the water cycle. Have them write from the drop’s point of view. You may want to assign students water drops that began their journeys in different places, such as a puddle on a farm, a mountain lake, a stream in a meadow, or a large ocean. Encourage students to use what they just learned, as well as their imaginations, to tell an interesting story. To spark imaginations, prompt students with these questions:

- Where did the water drop go on its journey?
- What did it see? What adventures did the drop have?
- How did it feel at different times?
- Did the drop meet any plants, animals, or people? If so, how did the water drop help them?
- How long did the drop’s trip take?
- Where does the water drop want to go on its next journey?

6. Discuss students’ stories and the importance of oceans.
Invite volunteers to share some of the adventures they wrote about in their stories. Ask: Why are oceans important? Discuss how they are not only the source of most of the water we use, but also a place where many animals live. If we want to keep our planet healthy, we must take good care of the oceans.

Extending the Learning

Conduct a simple science experiment so students can see firsthand how water evaporates, condenses, and precipitates. Fill a plastic cup halfway with water, place it inside a re-sealable plastic bag, close the bag, and set it on a sunny windowsill. Ask students to imagine that the water in the cup is the ocean, and have them check it daily to observe what happens. As students make observations, connect their observations to the processes of evaporation, condensation, and precipitation. Explain to students that each day the water level gets lower as water evaporates. The top of the bag gets cloudy as water condenses. And eventually water drops appear on the side of the bag and at the bottom as the water precipitates.

Background Information

Our ocean contains 97% of the Earth's water, most of which has been on Earth since the ocean formed more than four billion years ago. This water is in constant motion—evaporating into the air, condensing and precipitating onto land or water, and traveling back to the ocean where the never-ending water cycle begins again. Understanding the water cycle and the ocean’s role in it can help increase students' appreciation for the planet’s ocean.

Prior Knowledge

- None

Subjects & Disciplines

- Geography
  - Physical Geography
Learning Objectives

Students will be able to:

- state that most of the Earth’s water is in the ocean
- describe how drops of water move in an ongoing cycle through the processes of evaporation, condensation, and precipitation
- list some ways in which humans benefit from the water cycle
- explain why humans have tended to settle near sources of water
- express a desire to help preserve the ocean and its water

Teaching Approach

- Learning-for-use

Teaching Methods

- Brainstorming
- Discovery learning
- Discussions
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Skills
  - Information, Media, and Technology Skills
    - Information Literacy
  - Learning and Innovation Skills
    - Creativity and Innovation
- Critical Thinking Skills
  - Analyzing

Connections to National Standards

IRA/NCTE Standards for the English Language Arts

- **Standard 12**: Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

National Council for Social Studies Curriculum Standards

- **Theme 7**: Production, Distribution, and Consumption

National Geography Standards

- **Standard 1**: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information
- **Standard 3**: How to analyze the spatial organization of people, places, and environments on Earth’s surface

National Science Education Standards

- **(5-8) Standard B-1**: Properties and changes of properties in matter
- **(K-4) Standard D-1**: Properties of earth materials
- **(K-4) Standard D-2**: Objects in the sky
- **(K-4) Standard D-3**: Changes in earth and sky

Recommended Prior Activities
Vocabulary

- **cloud**
  - **noun**
  - visible mass of tiny water droplets or ice crystals in Earth's atmosphere.

- **condensation**
  - **noun**
  - process by which water vapor becomes liquid.

- **evaporation**
  - **noun**
  - process by which liquid water becomes water vapor.

- **gas**
  - **noun**
  - state of matter with no fixed shape that will fill any container uniformly. Gas molecules are in constant, random motion.

- **liquid**
  - **noun**
  - state of matter with no fixed shape and molecules that remain loosely bound with each other.

- **ocean**
  - **noun**
  - large body of salt water that covers most of the Earth.

- **precipitation**
  - **noun**
  - all forms in which water falls to Earth from the atmosphere.

- **vapor**
  - **noun**
  - visible liquid suspended in the air, such as fog.

- **water cycle**
  - **noun**
  - movement of water between atmosphere, land, and ocean.

For Further Exploration

Websites

- National Geographic Kids: Green Scene—I Am the Ocean
- National Geographic Environment: The Ocean
- NOAA: Water Cycle
The amount of water flowing through the Amazon Basin varies from month-to-month, and can be monitored from space by looking at how it alters the Earth's gravity field. This series of images was produced using data from NASA's Gravity Recovery and Climate Experiment (GRACE) and shows month-by-month water mass changes (relative to a 3-year average) over the Amazon and neighboring regions. Oranges, reds, and pinks show where gravity is lower than average; greens, blues, and purples show where gravity is higher than average. The Amazon has distinct rainy and dry seasons, and the seasons show up clearly in the monthly maps. Notice also that the smaller Orinoco Basin to the north of the Amazon has a distinctly different seasonal pattern. (Image credit: University of Texas Center for Space Research)
Overview of the Program

At present, an array of Earth observing satellites are in orbit, and additional launches both by NASA and others will continue throughout the next decade. Our ability to observe our home planet from space has never been greater. Increasingly, studies of the Earth focus on understanding the Earth’s land, atmosphere, oceans, and life as a whole integrated system rather than as independent elements. NASA is an important contributor in this systems approach to Earth science studies.

In addition to providing Earth observing capabilities, NASA forms strategic partnerships with other government, academic, private, and international organizations. Through these partnerships, NASA’s Earth science observations and measurements are linked to practical applications. NASA data, information, and predictive models help NASA’s partners, and nontraditional users of Earth science, make timely and accurate decisions regarding management of resources and development of policy. The agency’s goal is to maximize the benefit of science and technology to stakeholders by smoothly flowing Earth science data and information from NASA satellites to society.

Water Management

The Earth is easily distinguishable from other planets in our solar system by the abundance of water on its surface. Water covers approximately 70% of our world’s surface, so it would seem that finding enough water suitable for human consumption, commerce, and ecosystems is a trivial task. However, only 2.5% of the Earth’s water is fresh and, of that amount, more than two-thirds is locked away in glaciers and polar ice caps and is not available for use by society. Therefore, fresh water is actually a limited resource, and increased demand from an ever-growing population threatens to deplete precious water resources.

Not only is having water in sufficient quantity a concern, but there is also a need to ensure the quality of the available water supply. The nation must protect the quality of water flowing above ground in oceans, lakes, rivers, and streams, as well as water stored deep beneath the surface in aquifers. Decision makers need accurate and dependable information on water availability (e.g., from surface reservoirs, snowpack, underground aquifers, etc.) and on water quality to help them respond to the needs of society.

The water management program element in the Applied Sciences Program of the Earth Science Division in NASA’s Science Mission Directorate responds to society’s need for accurate information on fresh water availability and quality. It extends products that result from NASA’s Earth science research models, technology, etc., into tools that decision makers can use to help with water management issues such as:

- Estimating water storage—e.g., snowpack, soil moisture, aquifers, lakes.
- Assessing, modeling and predicting water fluxes—e.g., evapotranspiration, precipitation, river runoff.
- Remote sensing of water quality—e.g., turbidity, dissolved oxygen.

NASA’s Earth observing satellites contribute important environmental information concerning the availability of fresh water. The Moderate Resolution Imaging Spectroradiometer (MODIS) and Clouds and the Earth’s Radiant Energy System (CERES) instruments on the Terra and Aqua satellites are helping to refine our estimates of the Earth’s surface energy balance, which helps improve our understanding of evaporation over the Earth’s surface. The Advanced Microwave Scanning Radiometer-EOS (AMSR-E) instrument on Aqua measures surface soil moisture and snow-liquid water equivalent. This information should help scientists better understand the processes that affect soil moisture, so that they can be accurately represented in models.

Data from the Gravity Recovery and Climate Experiment (GRACE) helps scientists monitor changes in water storage over large areas as illustrated on the front of this lithograph. Gravity changes correspond to mass changes and scientists can isolate the portion of the total mass change caused by the movement of water. Hydrologists go a step further and combine information from GRACE with soil moisture and other data to isolate changes in groundwater storage, allowing them to monitor monthly water storage changes in aquifers. The Tropical Rainfall Measuring Mission (TRMM) satellite monitors tropical/subtropical precipitation and provides important new information on rainfall properties and their variation. The Global Precipitation Measurement (GPM) mission is planned as a follow-on to TRMM and will provide much-improved spatial coverage and round-the-clock observations of precipitation.

With regard to monitoring the quality of water from space, MODIS is useful for monitoring water quality in larger lakes, sediments both along the coast and in larger rivers, and pollutants (e.g., red tide). In addition, the Enhanced Thematic Mapper Plus (ETM+) on Landsat 7 and the Hyperion instrument on the Earth Observing-1 satellite obtain visual images of the surface of the Earth at a higher spatial resolution than MODIS that can be analyzed to track changes in water quality over time. Future observations, planned as a continuation of Landsat, should further enhance our ability to monitor water quality from space.

NASA Earth observing satellites thus provide a unique viewpoint for collecting information that is useful for water management decision making. The real value of this information is realized when data collected by these NASA missions are input into models that simulate the actual conditions and the results are used to serve society. Incorporating this information into computer simulations used to aid water management decision making as described above will lead to improved capability to predict water availability, protect water quality, and plan water conservation. NASA partners with Federal agencies such as the Environmental Protection Agency and the Bureau of Reclamation and with other organizations that have water management responsibilities and mandates to support water resource managers. The program also includes activities with international organizations, particularly through involvement of U.S. partner organizations.