OCEAN ACIDIFICATION

Role Play and Activity Sheet

Global Issue: Ocean Acidification

Target Grade Level: 11^{th} - 12^{th}

Key Questions: What are the impacts of ocean acidification and what can be done to reduce those impacts?

Student Learning Objectives:

The student will be able to:

1. Relate the properties of water to the requirements of living organisms. (SC.A.1.4.5, SC.F.1.4.1)
2. Use an expository writing style to explain how large bodies of water, such as, oceans and lakes moderate weather. (SC.D.1.4.1, SC.D.1.4.3)
3. Identify interconnections between water and humans. (SC.D.2.4.1, SC.G.1.4.1, SS.B.2.4.4)
4. Associate human population growth with ocean acidification. (SC.G.2.4.4, SC.G.2.4.5, SC.G.2.4.6, SS.B.2.4.5)
5. Develop and verbally present a strategic plan to counter the effects of ocean acidification. (LA.B.1.4.1, LA.C.3.4.4)
6. Evaluate the relevance of their peer's presentations to the defined topics.

List of Materials:

- Standard High School Biology textbooks (1 per student)
- World Atlas (1 per student)
- Laminated Role Play Cards
- Photocopies of the Student Scenario & Student Instructions (30 copies of each)
- Photocopies of the Student Worksheet (5 copies per class period)
- Photocopies of the Conference Presentation Evaluation form (1 per student)

Background Information

Like a global vacuum cleaner our oceans absorb a vast amount of carbon dioxide released from automobile tailpipes, coal burning factories, and hydropower plants through a process known among scientist as "ocean acidification." Among non-scientist the phrases "Osteoporosis under the sea", "Dissolving coral reefs", and "Peril at the poles" more appropriately characterizes the magnitude of the situation. Since the start of the Industrial Revolution, hundreds of billions of greenhouse gases have been swallowed by the oceans, imperiling coral reefs and marine creatures at all levels of the food chain. Yet, unlike global warming which has been debated for decades, ocean acidification is not being debated as it involves straight forward chemistry that everyone understands.

Ocean sea water is normally slightly alkaline, but when carbon dioxide dissolves into the water, carbonic acid (a weak acid that helps give soda its fizz) forms. The presence of the carbonic acid lowers the water's pH which not only makes the water more acidic, but it also robs the water of carbonate, a key ingredient in the formation of

calcium-carbonate shells. This is obviously a serious problem for organisms with a calcium carbonate shell like clams, oysters, and the microscopic plankton that make up the base of the marine food chain. On the flip side, organisms such as cyanobacteria, dinoflagellates, and seaweed benefit in these conditions, but for different reasons. For example, seaweed doesn't benefit directly from increased ocean acidification; rather it competes with coral for light and space. So, if you eliminate the coral you favor the seaweed. Wereas, cyanobacteria benefit directly from the increased levels of carbon dioxide in ocean because they can use it for manufacturing chemical energy.

But, ocean acidification isn't just an issue for organisms living in the ocean; it's also an issue for those living on land. For people living in coastal communities the coral reefs shield them from wave and storm surges, provide a wealth of food resources, and generate big dollars from tourism. On a global scale, ocean acidification impacts fish and pharmaceutical industries. An estimated 100-200 million people worldwide depend on marine food as primary source of food and a main source of protein, and everyone country has needs for new affordable drugs. It's for those reasons that organizations such as UNEP, AMRF, PRMED, IWMI, and ICMEE meet annually to discuss the issues and share their strategic plans for educating the public about ocean acidification, restoring coral reefs, and managing marine food supplies for the communities around the world that depend on them.

Student Scenario

Each of you has been cordially invited to represent your organization at the Global Marine Ecosystem Watch (GMEW) conference held annually in Aspen, Colorado. GMEW is an organization composed mostly of extremely wealthy investors interested in countering the impacts of ocean acidification. Each year they organize a conference at a luxurious resort in Aspen to award lucrative sums of money to organizations dedicated to the cause. This is a very prestigious conference in which only top associates of a select few organizations are invited to share their strategic plans for countering the impacts of ocean acidification. This year five organizations have been invited to the conference: The Regional Seas Programme of the United Nations Environmental Programme (UNEP), Algalita Marine Research Foundation (AMRF), The Economic Policy and Debt Department of the World Bank (PREM), International Water Management Institute (IWMI), and The International Coalition of Marine Ecosystem Experts (ICMEE). These organizations were chosen by the GMEW foundation members for their long standing dedication to the cause and the unique services they provide.

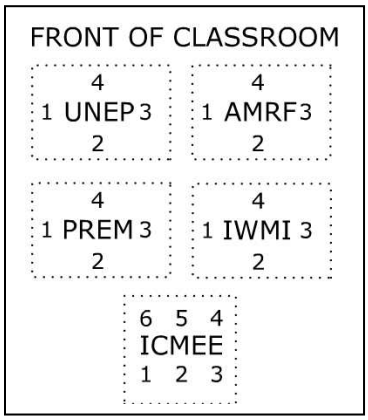
Each organization will be given an opportunity to present their strategic development plan for countering the impacts of ocean acidification and a chance to receive a portion of the funds being awarded. Six awards totaling $3.5 million dollars will be available in part to the organization that presents the best strategy for addressing issues relating to world hunger ($1 million), restoring coral reefs ($1 million), educating the public about carbon dioxide emissions and ocean acidification ($500,000 x 2), and removing garbage from the oceans ($250,000 x 2). After each organization presents their strategic plan, the president of the GMEW foundation (the teacher) will decide which organizations receive the funds.

Teacher Instructions

This role-play activity will take two days. By the end of the first day students should have completed the *Warmup* and *Strategic Development Plan* sections of the Student Worksheet. On the second day students will present their plans and score their peer's presentations.

Day 1

- Photocopy all the handouts listed in *Materials*.
- Role cards need to be copied according to the number of roles listed. For example, you need four copies of the UNEP card and six copies of the ICMEE card. Laminate all the role cards.
- The Scenario and Student Instructions will be reused each class period so you will only need 30 copies. Each group of students will complete a single Student Worksheet, so you need to copy enough to accommodate five groups for each period.
- On the morning of the activity arrange the desks into groups according to the diagram show on the right, which is based on the number of roles per organization. For example, UNEP would have four desks grouped together and ICMEE would have 6 desks grouped together. Each group of desks should be spaced far enough apart that students can easily navigate between them. As students arrive to class have them fill in the empty desks starting with the front groups. The ICMEE group should be filled last. It's probably a good idea to redraw this diagram on the board.



- Once students are all seated, hand them each a copy of the Student Scenario and Student Instructions and tell them NOT to write on those documents.
- Read the Background Information, Student Scenario.
- Hand out the role play cards and read the list of roles and their descriptions. Explain to the students that each of them will have a role to play in this activity that will require their complete and undivided attention. Failure to convincingly act out their role will result in loss of participation points. Individual roles are listed for each role play card. Students will need to assume a role and then define their role by writing a brief description of their responsibilities/duties in the organization in *Strategic Plan Development* section of the Student Worksheet.
- Hand one copy of the Student Worksheet to each group and explain that there are three parts to this activity and that you will tell them when to complete each part.
- Part I: Warmup (15 min)
    - Refer student to the *Warmup* section of the Student Worksheet and read the instructions to the class.
    - Students will have 10 minutes to complete this part.
    - After everyone has finished, randomly call on students from different organization to present their responses to the class.

- Part II: Strategic Plan Development (20 min)

- Refer student to the *Strategic Plan Development* section of the Student Worksheet and read the instructions to the class.
- Each organization has 20 minutes to prepare the plan they will present at the GMEW conference.
- Collect the Student Worksheets at the end of class.

Day 2

- Part III: GMEW Conference (entire class period)
  - At the start of class remind students to sit with the other members of their organizations.
  - Return the strategic plans and if necessary give students an extra 5 minutes to finalize them, otherwise, proceed with the conference presentations.
  - Refer student to the *GMEW Conference* section of the Student Worksheet and read the instructions to the class.
  - Each organization will have no more than 10 minutes to present their strategic development plan. The order of presentations is not important; however, it is important that each member of the organization presents at least one section of the plan. The presentation guidelines are as follows:
    - Only one member should be standing at a time and members will speak in the order shown in the diagram, which is basically counter-clockwise starting with member #1. After each member presents one part of the plan, he/she passes the Student Worksheet to the next student and sits down.
    - Each member will introduce themselves by stating their name and role in the organization. Students will refer to the role information they wrote in the plan.
    - Member # 1 in each organization will start the presentation by reading the Role Card and the information contained in Part-A of the plan. Since Part-B of the plan consists of four questions, each member of the group will have a chance to present at least once. Members of the ICMEE organization may need to divide the plan into smaller sections to accommodate all the members.
  - In addition to presenting a strategic plan, each organization will also score each others presentation so that the GMEW foundation committee (the teacher) can determine which organizations receive awards.
    - The first four topics in the scoring table relate directly to questions 1-4 of Part-B of the strategic development plan. The last topic relates to the overall quality and effort of the presentation.
    - At the end of each presentation the members of the other organizations will have 2 minutes to discuss and score the presentation. STUDENTS SHOULD NOT BE SCORING DURING THE PRESENTATION.
  - After all the organizations have presented their plans you will collect the Student Worksheets, determine which organizations received the most points for each topic, and present the awards. The awards will be presented as extra credit points.

STUDENT INSTRUCTIONS

Warmup

Your organization's first task is to complete the *Warmup* section of the Student Worksheet and for that each of you will need a copy of the Biology textbook and World Atlas. Discuss the questions among yourselves and write responses based on the group consensus. Be prepared to share your responses with the rest of the class. You have about ten minutes to complete this section.

Strategic Plan Development

Each of you is an important member of an organization that's dedicated to countering the impacts of ocean acidification and also very interested in receiving a portion of the funds. You will have 20 minutes to create a strategic development plan to present at the GMEW conference. Remember, you're competing with other organizations for a share of the awards so your plan needs to be top quality, but most importantly it needs to address one of the topics that qualify for the awards. The topics being awarded are listed below. Choose two of the following topics and complete the Strategic Plan Outline on the Student Worksheet.

- Dealing with issues relating to world hunger
- Restoring coral reefs
- Educating the public about carbon dioxide emissions and ocean acidification
- Cleaning up the garbage in the oceans

GMEW Conference

Today your organization will present its strategic plan at the GMEW conference. In addition, your organization will also be scoring presentations given by other organization so that the president of the GMEW foundation (the teacher) can decide how the available funds will be distributed.

You will have ~10 minutes to present your plan. Organization Member #1 will start the presentation by stating his/her role title and responsibilities/duties in the organization, and presenting Part-A of the strategic development plan. Then rotating counter-clockwise each member will present a different section of the plan until the entire plan has been presented.

After each presentation there will be a 2 minute recess period during which time the other organizations will use the score sheet to score the presentation. Do not score your own presentation. After all the presentations are finished the president of the GMEW foundation (the teacher) will total the scores and present the awards. Instead of "real" money, the awards will be given as extra credit points as determined using the following formula: ($ Award Amount)/$100,000. For example, each member of the organization that receives both a $500,000 and a $250,000 award would receive 7.5 extra credit points.

STUDENT ROLE PLAY CARDS

UNEP (United Nations Environmental Programme) - Regional Seas Programme

The Regional Seas Programme addresses the degradation of the world's oceans and coastal areas and engages neighboring countries in comprehensive and actions to protect their shared marine environment. Today, more than 140 countries participate in Regional Seas programmes that are coordinated and implemented by those countries that share a common body of water. Members of this programme work together with government officials from different countries to keep their bordering waters clean, and manage their fisheries appropriately. This organization already has established connections with government officials and institutions around the world which makes it much easier for them to deploy transboundary initiatives.

ROLES: UNEP Senior Director, Regional Seas Programme Director, Ocean Ecologist, Pollution Cleanup Coordinator.

Algalita Marine Research Foundation (AMRF)

AMRF is a non-profit research foundation dedicated to protecting the marine environment and watersheds through research, education, and restoration. The mission of AMRF is to document anthropogenic contamination and destruction, and develop strategic plans for restoration. AMRF employs a group of world-recognized experts that understand the impacts of plastic contamination on the world's oceans and recognizes that the health of the marine environment is an international issue all humans share in common. AMRF has already been working over ten years to cleanup the "Great Pacific Garbage Patch" which is considered by many to be the world's largest garbage dump.

ROLES: Educator, Coral Restoration Expert, Trolling Supervisor, Humanitarian

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The Economic Policy and Debt Department (PRMED)

PRMED is a unit of the World Bank responsible for the Bank's work on economic policy and financing for growth. They are deeply concerned with the acidification of the oceans since it will effect economic growth worldwide, especially in the Heavily Indebted Poor Countries (HIPC). There are four major areas PREMED is concerned with: (1) Tourism, which provides up to 25% of the total gross domestic product for many island nations, particularly those in the Caribbean. (2) Coastal Communities, which rely on coral reefs to protect their infrastructure and revenue generating businesses from wave and storm surges. PRMED is concerned that with the loss of coral reefs, these communities may suffer great economic losses in the event of a hurricane or tropical storm. (3) Pharmaceuticals – Drugs used to treat cancer and AIDS would be lost if ocean acidification were allowed to proceed. (4) Fisheries – Globally 38 million people are employed by fish-related industries and more than a billion people – mostly in the developing world – rely on fish as their main source of protein. Acidification of the oceans would cause greater economic loss to an industry already suffering from depleted fish stocks due to poor management and overexploitation.

ROLES: Expert Economic Advisors on Tourism, Coastal Communities, Pharmaceuticals, and Fisheries

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International Water Management Institute (IWMI)

IWMI is non-profit organization and one of 15 international research centers supported by a network of 60 governments concerned with improving the management of land and water resources for food, livelihoods and nature. IWMI targets water management challenges faced by poor communities in developing countries. Through this initiative IWMI contributes towards the achievement of the UN Millennium Development Goals (MDGs) of reducing poverty, hunger and maintaining a sustainable environment. IWMI has a staff over 300 already working in many different countries and has good relations with various humanitarian groups.

ROLES: Chemist, Coral Expert, Biological Oceanographer, Humanitarian

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The International Coalition of Marine Ecosystem Experts (ICMEE)

Known around the world as "aquatic problem solvers" the ICMEE are an international group of scientist that dedicate their lives to providing solutions to problems involving marine ecosystems. Some of the ideas already proposed by ICMEE include: Seeding ocean surfaces with iron to promote phytoplankton, neutralizing the seas with limestone, and developing technology that would engineer weather patterns. Because members of the ICMEE are distributed world wide there are no predetermined roles. Each member of the organization essentially creates his/her own role as they join the team. Examples of past roles include a Senior Hydrotech Engineer, Aerospace Electrical Cosmetologist, Global Humanitarian Marine Activist, and Professor Emeritus of Earth Space Science. As new members join the team, new roles will be developed.

ROLES: TBD

Period:_____

STUDENT WORKSHEET

Instructions

There are three parts to this worksheet (Warmup, Strategic Plan Development, and GMEW Conference). The teacher will tell you when it's time to complete each part. The instructions for each part are listed below and described briefly in the Student Instructions document. In the space provided, write the name of your organization and list the first and last names of the organization members.

Organization:

Members:

Warmup

List any three properties of water and explain (1-2 sentences) how each property meets the requirement of living organisms.

a)

b)

c)

Search through the world atlas and find four large bodies of water (a large body of water would be a lake, sea, or ocean). In the space provided write the name of the body of water and countries that border it. Then, briefly explain how each body of water potentially affects the lives of the people living in the bordering countries. Do not use the same explanation more than once.

Body of Water	Bordering Countries	Explanation

List 15 interconnections between water and humans. Interconnections should be described in one complete sentence, and need to be specific. For example, don't just say "water is used to grow food", instead, say something like, "Humans use vast amounts of water to irrigate their crops" or "Lot's of water is used to flush fecal waste from American homes."

[WATER] **INTERCONNECTIONS** **[HUMANS]**

(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)
(11)
(12)
(13)
(14)
(15)

Strategic Plan Development

Your chances of receiving one or more of the awards will be based on the quality, detail, and relevance of your plan. In the space provided list the roles and a brief description (1-2 sentences) of responsibilities/duties of each role in the organization.

Roles **Responsibilities/Duties**

(A) Choose two award topics your organization will pursue. In the space provided list the award topics and explain (2-3 sentences) why your organization feel it's the most qualified to pursue that topic.

Award-Topic 1:

Award-Topic 2:

Since ¾ of the Earth is covered in oceans there are many great locations where organizations can deploy their strategies to counter the impacts of ocean acidification.

In what parts of the world would your organization be working towards that cause? List three specific locations (Refer to the World Atlas for country name and body of water) and explain (1-2 sentences) why your organization chose those locations.

Location 1:

Location 2:

Location 3:

(B) Your responses to the following questions will be used to decide whether your organization qualifies to receive awards or not, so they should be written to both inform and please the audience. Your responses should be written in 5-8 sentences.

1) One of the major consequences of ocean acidification is world hunger. How would your organization reduce the impact of ocean acidification on marine food resources? Consider food resources at the base of the food chain (Plankton), those at that top (whales, sharks), and the fisheries industry.

2) The destruction of coral reefs impacts the coastal communities that rely on them for storm protection, food resources, and tourism. How would you protect and restore coral reefs?

(3) If the average person was more informed about the effects of carbon dioxide emissions on marine life they might consider strategies for reducing their personal pollution footprint.

How would your organization educate the general public about the effects of ocean acidification?

Would your organization choose to educate people in developed or undeveloped countries or both? Explain.

(4) In addition to the carbon dioxide emissions, millions of tons of garbage are also being dumped into the oceans every year.

How would your organization cleanup the garbage dumps accumulating in the oceans?

What would your organization do to reduce the amount of garbage that enters the oceans?

GMEW Convention

In addition to presenting your strategic plan for countering the effects of ocean acidification, your organization will also be scoring presentations. The awards will be handed out to the organization with the most number of points for that particular award topic. Use the following table to score the presentations, but do not score your own. You will have 2 minutes after each presentation to score them, so DO NOT score during the presentation.

Score each on a scale of 0-2:

0 - Organization's plan does not address this issue

1 - Organization's plan addresses this issue, but does not provide detailed strategies for dealing with the issue.

2 - Organization's plan addresses this issue and provides detailed strategies for dealing with this issue.

* Quality of presentation – Up to an additional 3 points can be awarded for the quality of the presentations.

	UNEP	**AMRF**	**PREM**	**IWMI**	**ICMEE**
Focus on world hunger					
Restoration of coral reefs					
Educating the public					
Cleaning up the garbage					
* Quality of presentation					

Resources/References

Algalita Marine Research Foundation (AMRF)
http://www.algalita.org/

European Project on Ocean Acidification (EPOCA)
http://oceanacidification.wordpress.com/

International Water Management Institute (IWMI)
http://www.iwmi.cgiar.org/

The Economic Policy and Debt Department (PRMED) of the World Bank
http://web.worldbank.org

UNEP (United Nations Environmental Programme) - Regional Seas Programme
http://www.unep.org/regionalseas/

Ocean acidification
http://www.seafriends.org.nz/issues/global/acid.htm

Thomas Kostigen. "Better Planet. The World's Largest Dump: The Great Pacific Garbage Patch" Discover Magazine July 2008: 24-26.

Kathleen McAuliffe. "Ocean Reflux" Discover Magazine July 2008: 28-37.