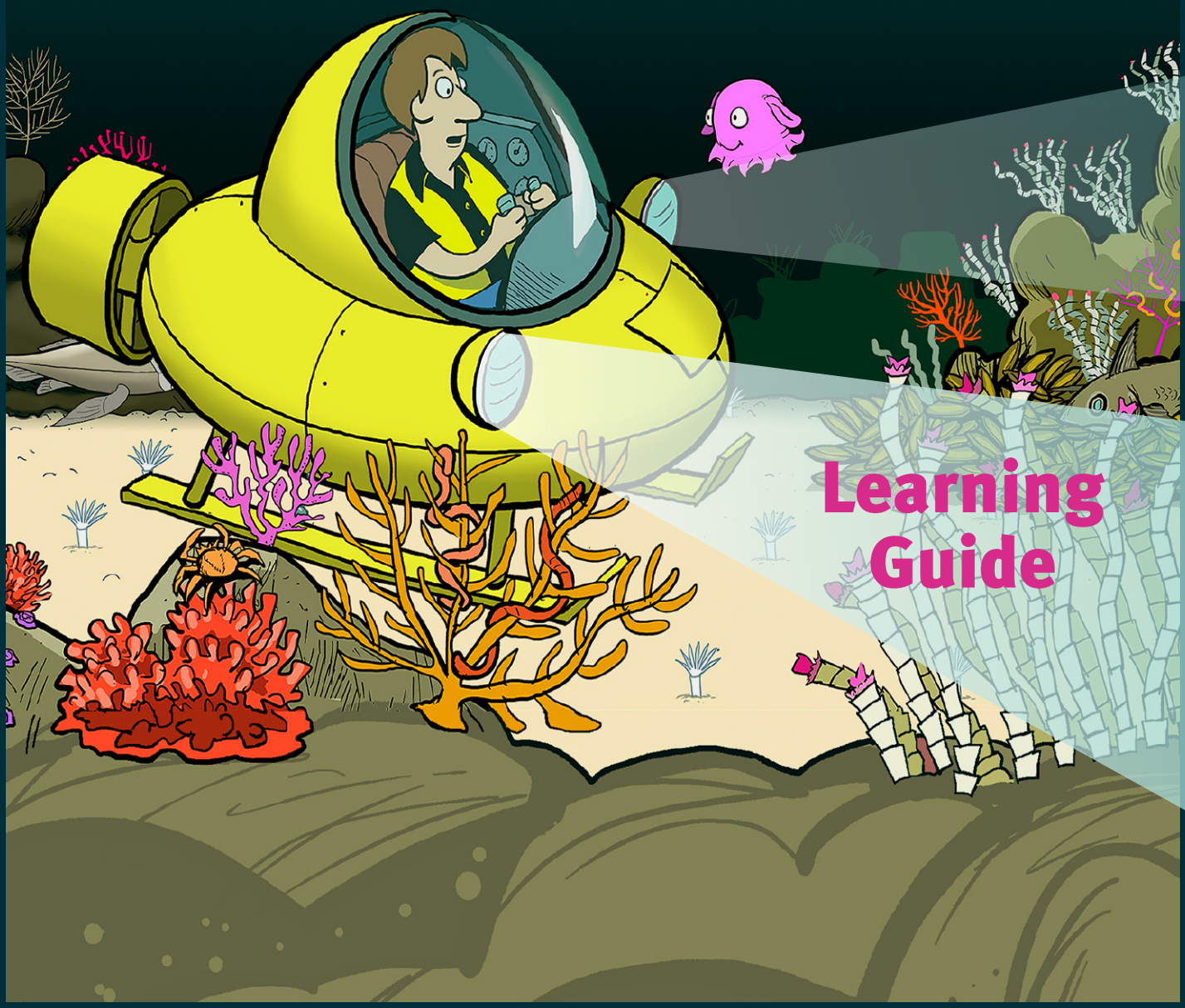
The Adventures of ZACK AND MOLLY



Learning Guide

diving deeper

Discussion Topics, Further Resources and Connections to Next Generation Science Standards

- **Where does a dumbo octopus *really* live and what is its ecology?**

  (K-ESS3-1, 3-LS4-4, 3-LS1-1, 4-LS1-1, MS-LS2-2)

  - Learn more about the dumbo octopus
  - Video footage of a dumbo octopus

- **What benefits do healthy oceans provide humans?**

  (5-ESS2-1, MS-ESS2-6, HS-ESS2-5)

  Oceans stabilize climate, produce oxygen, sequester carbon, provide food and other natural resources and protect our coasts from storms.

  - Learn more about the benefits of healthy oceans

- **What is the connection between our society's demand for energy and the ocean?**

  (5-ESS3-1, MS-PS1-3, HS-ESS3-3, HS-ESS3-6)

  Our production of greenhouse gases contributes to a warming and acidifying ocean, and our extraction of oil and natural gas from beneath the ocean floor puts the ocean and the health of the planet at risk.

  - Learn more about U.S. energy consumption
  - Calculate your carbon footprint
  - Ocean acidification
  - Coral bleaching and ocean warming

- **What is the importance of energy production to the Gulf Coast economy?**

  (4-ESS3-1, MS-ESS3-4, MS-PS1-3, HS-ESS3-3)

  The Gulf of Mexico area, both onshore and offshore, is an important region for energy resources and infrastructure. In addition to offshore crude oil and natural gas production, over 45% of total U.S. petroleum refining capacity is located along the Gulf coast, as well as 51% of total U.S. natural gas processing capacity.

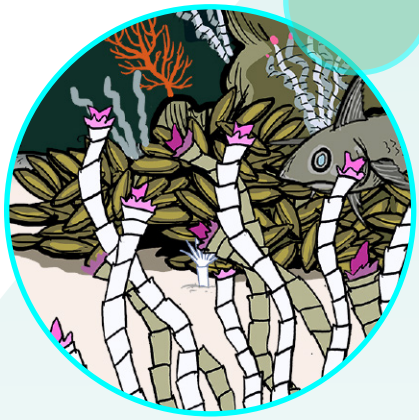
  - Map showing wells and oil rigs in the Gulf of Mexico
  - Many lives and livelihoods are dependent upon the energy sector in the Gulf. The oil and gas industry employs 2.7 million people across the entire Gulf Coast.

• What is a cold seep and why are there so many in the Gulf of Mexico?

(2-ESS1-1, 4-ESS3-1, MS-ESS3-1, MS-ESS2-2, HS-LS2-5, HS-ESS3-6, HS-ESS2-1)

A cold seep is an area where hydrogen sulfide, brine, methane, and other hydrocarbon-rich fluids "seep" out of the ocean floor. Cold seeps occur over fissures in the sea floor caused by tectonic activity or squeezing of the sediments below the surface. Concentrated saltwater, oil and gases move through the fissures in the rock and sediment and emerge at different points of the seafloor.

- NOAA Ocean Explorer's guide to cold seeps, with activities and learning resources



• How has life adapted to living at cold seeps?

(K-LS1-1, 3-LS4-3, 4-LS1-1, 5-LS2-1, MS-LS1-5)

Specialized organisms have evolved to use chemicals emanating from cold seeps as an energy source.

- Chemosynthetic communities in the Gulf of Mexico

• What fuels the deep sea food web in the absence of sunlight?

(K-LS1-1, 2-LS2-1, 3-LS3-2, 5-LS2-1, MS-PS1-2, MS-LS2-2, HS-LS2-5)

There are two parallel food webs that exist on our planet – one fueled by photosynthesis, where sunlight is the main source of energy and one fueled by chemosynthesis, where chemicals are the main source of energy.

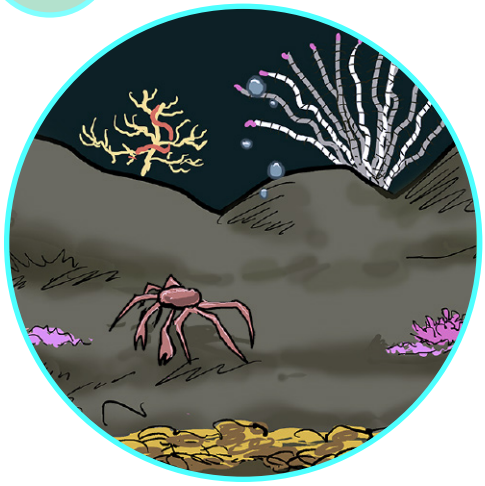
- What is the difference between chemosynthesis and photosynthesis?
- Chemosynthesis video from Nautilus Live

• How do microbes and deep sea organisms (such as mussels and tube worms) work together to use methane, oil and other chemicals for a food source?

(3-LS3-2, 3-LS4-3, 4-LS1-1, 5-LS2-1, MS-LS1-3, MS-LS2-2, MS-PS1-2, HS-LS1-2)

Microbes and some deep sea creatures have a symbiotic relationship. Inside the bodies of these specialized animals are bacteria that convert chemicals from hydrothermal vents or cold seeps into organic molecules that provide food for the animal.

- Cold seep tube worms



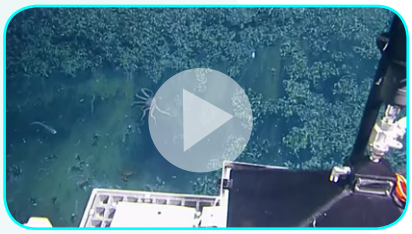
• What are brine pools and how do they form?

(2-ESS1-1, 3-LS4-3, MS-ESS3-1, MS-ESS2-2, HS-ESS2-1)

Brine pools often occur in conjunction with cold seeps. They form over fissures in the seafloor caused by tectonic activity or squeezing of the sediments below the surface.

Concentrated saltwater, oil and gases move through the fissures in the rock and sediment and emerge at different points of the seafloor. The salty water that seeps out is up to four times more dense than the ocean water, so it settles on the bottom as a brine lake or pool instead of mixing with the water above it.

BRINE POOL VIDEOS:



• What is a deep sea coral and what is its ecology?

(3-LS1-1, 3-LS2-1, 3-LS3-1, 4-LS1-1, 5-LS2-1, MS-LS1-5, MS-LS2-1, MS-LS3-2, HS-LS2-8)

Deep sea corals (corals living below the sunlit zone of the ocean) are slow-growing and known to live for hundreds to thousands of years. Unlike shallow-water corals, deep sea corals don't need sunlight for their nutrition – they do not have symbiotic algae inside their tissues. They obtain the energy and nutrients they need to survive by trapping tiny organisms in passing currents. Over 3,000 species of deep sea coral have been identified. There are nearly as many deep sea coral species as shallow water coral species.

- More information about deep sea corals
- Photos of deep sea corals

• What benefits do deep sea corals provide for other organisms?

(3-LS2-1, 3-LS4-3, 5-LS2-1, MS-LS2-1, MS-LS2-2, HS-LS2-8)

Deep sea corals are an important habitat for animals such as crabs, squat lobsters, anglerfish and chimera. Many fish, especially during their juvenile stages spend part of their lives on or near the seafloor.

- More information about deep sea corals as habitat and the ecosystems they create

• What is bioluminescence and how does it occur?

(1-PS4-2, 4-LS1-1, 4-LS1-2, 4-PS4-2, MS-LS2-2)

Bioluminescence is the biochemical emission of light by an organism, and in the deep ocean it helps deep sea animals communicate, warn others, confuse predators, lure prey and attract mates. Bioluminescence occurs through a chemical reaction that produces light energy within an organism's body. In some cases, animals take in bacteria or other bioluminescent creatures to gain the ability to light up.

- More information about bioluminescence

• What human activities threaten the deep ocean?

(MS-LS2-4, MS-ESS3-5, HS-ESS3-6, HS-LS2-7, HS-ESS3-4)

Deep sea trawling and other destructive fishing practices, deep sea mining, energy exploration (seismic testing, which interferes with navigation, communication, and finding food for marine animals), energy extraction (oil rig accidents, spills, leaks), chemical and plastic pollution.

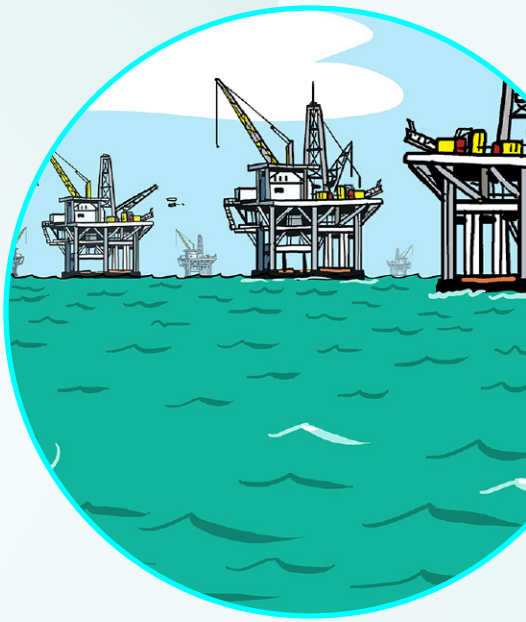
- National Geographic lessons on human impacts on the world ocean
- Threats to our ocean
- Threats to the deep ocean

• What are some ways we can reduce our impact on the ocean in general, and the deep sea in particular?

(K-ESS3-3, 5-ESS3-1, MS-ESS3-3, MS-LS2-2, MS-LS2-4, HS-ETS1-4, HS-ESS3-1, HS-LS2-7, HS-ESS3-4)

Examine your daily life and ask what individual actions you can take to protect the ocean (see page 8 of this guide), and what you can do in your school, institution or community. Support organizations working to effectively protect the ocean. Vote responsibly. Put pressure on policymakers who hold governments accountable to meet their ocean protection commitments.

- Printable wallet cards "10 ways to protect the Ocean/Gulf of Mexico"



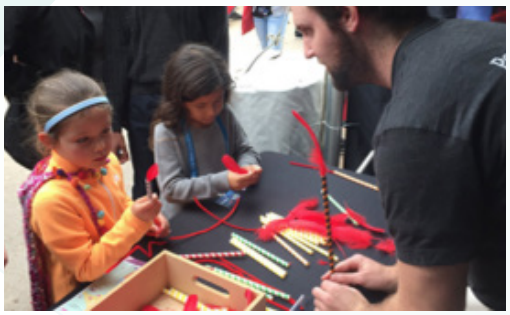
hands-on learning

These activities are an opportunity for students to learn more about oil spills and how deep sea animals have adapted to living at depth. Visit ecogig.org/printables or click on the links below to access activity guides.

Oil Spill Clean Up

Learn about the 2010 Deepwater Horizon oil spill and the challenge of removing oil from the ocean.

Adapted by ECOGIG from an activity developed by Cynthia Cudaback.



Build A Deep Sea Tube Worm

Learn about the anatomy of a tube worm and its unique way of obtaining energy from the deep sea. © ECOGIG

Build A Deep Sea Coral

Learn about the architecture of deep sea corals, the habitat they provide for other animals, and their unique way of living without sunlight or photosynthesis as their food source. © ECOGIG

Bioluminescent Light Paintings

Students can create their own 'paintings' of bioluminescent organisms with glow sticks or flashlights.

© Smithsonian Ocean Portal
https://ocean.si.edu/ocean-life/using-light-painting-teach-bioluminescence

Build An Edible Coral Polyp

Learn about the basic anatomy of a coral and why corals are animals, not plants.

© California Academy of Sciences
https://www.calacademy.org/educators/lesson-plans/build-a-coral-polyp

printables

ECOGIG has developed a variety of resources about the deep ocean, including posters, wallet cards, postcards, and activities.

AVAILABLE PRINTABLES:

Deep Sea Tube Worms Poster (15” x 11”)

Amazing Deep Sea Corals Poster (17” x 11”)

Gulf of Mexico Deepwater Corals Poster (15” x 11”)

Why Is Our Ocean Stressed? Poster (10” x 17”)

Why is the Gulf of Mexico Stressed? Poster (9” x 17”)

Exploring Our Ocean Poster (10” x 17”)

Exploring the Gulf Poster (9” x 17”)

Healthy Ocean Ecosystems Poster (10” x 17”)

The Gulf of Mexico’s Amazing Ecosystems Poster (15” x 11”)

10 Ways to Protect the Gulf Foldable Wallet Card

10 Ways to Protect the Ocean Foldable Wallet Card

10 Ways to Protect the Ocean Postcard

The Adventures of Zack and Molly Poster

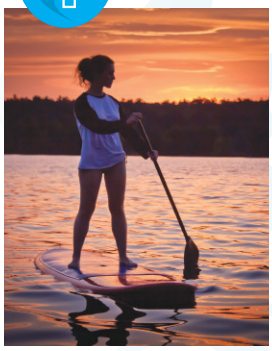
To download and print, go to:
ecogig.org/printables

10 ways to protect the ocean

THE OCEAN IS A VERY SPECIAL PLACE, BUT IT'S AN ECOSYSTEM UNDER STRESS.

Many factors, like overfishing, climate change, agricultural runoff, and oil exploration impact ocean ecosystems around the world. But there's hope, and it starts with you.

1 KEEP BEACHES & WATERWAYS CLEAN



Marine debris usually originates on land. Even if you live far from the coast, your litter ends up in the sea.

2 NO MORE MICROBEADS

Avoid products with microbeads – polyethylene particles widely used in toothpaste and exfoliating products.

3 REDUCE USE OF PLASTICS

Bring your own reusable drink and food containers and use cloth bags at the grocery store.

4 MAKE BETTER TRANSPORTATION CHOICES

Identify opportunities to ditch your car and walk, bike, or take public transportation.

5 REDUCE HOUSEHOLD ENERGY USE

Unplug items not in use, identify and resolve energy inefficiencies in your home.

6 EAT SUSTAINABLE SEAFOOD

Use a seafood guide to make better decisions. Consider seafood sustainability when choosing a diet for your pet.

7 USE FEWER GARDEN CHEMICALS

Pesticides and fertilizers seep into water sources and eventually into the sea.

8 USE NON-TOXIC CLEANING PRODUCTS

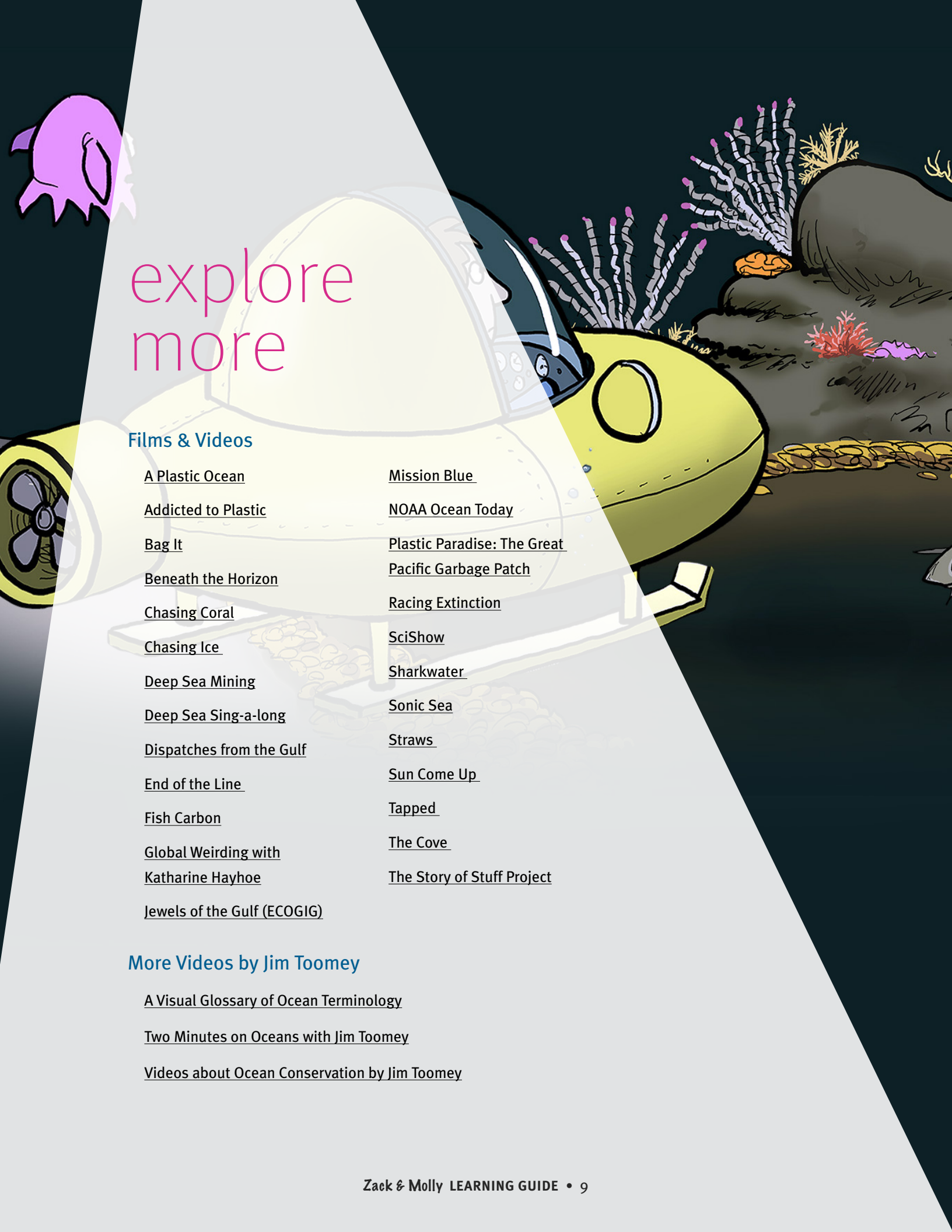
Simple, non-toxic ingredients like vinegar, baking soda, or lemon juice are effective household cleaners.

9 GET INVOLVED

Participate in beach cleanups, sign petitions, and vote to support legislators and laws that protect the ocean.

10 ENJOY THE OCEAN

Increase your connection to the sea by surfing, diving, beachcombing, sailing, paddle boarding, kayaking, or anything that brings you joy!



explore more

Films & Videos

A Plastic Ocean

Addicted to Plastic

Bag It

Beneath the Horizon

Chasing Coral

Chasing Ice

Deep Sea Mining

Deep Sea Sing-a-long

Dispatches from the Gulf

End of the Line

Fish Carbon

Global Weirding with Katharine Hayhoe

Jewels of the Gulf (ECOGIG)

Mission Blue

NOAA Ocean Today

Plastic Paradise: The Great Pacific Garbage Patch

Racing Extinction

SciShow

Sharkwater

Sonic Sea

Straws

Sun Come Up

Tapped

The Cove

The Story of Stuff Project

More Videos by Jim Toomey

A Visual Glossary of Ocean Terminology

Two Minutes on Oceans with Jim Toomey

Videos about Ocean Conservation by Jim Toomey

explore more

Ocean Science & Conservation

BBC Blue Planet
https://www.bbcearth.com/blueplanet2

Gulf of Mexico Research Initiative
http://gulfresearchinitiative.org

Mission Blue
https://mission-blue.org

Nautilus (Ocean Exploration Trust)
https://nautiluslive.org

Nekton Mission
https://nektonmission.org

Next Generation Science Standards
http://www.nextgenscience.org

NOAA Ocean Explorer
https://oceanexplorer.noaa.gov

NOAA Oceans and Coasts Educational Resources
https://www.noaa.gov/resource-collections/ocean-coasts-education-resources

Ocean Conservancy
https://oceanconservancy.org

Ocean Literacy Principles and Fundamental Concepts
http://oceanliteracy.wp2.coexploration.org/

OceanX
http://www.oceanx.org

Oil Spill Science Outreach (Sea Grant in the Gulf of Mexico)
https://gulfseagrant.org/oilspilloutreach

Schmidt Ocean Institute
https://schmidtocean.org

Smithsonian Ocean Portal
https://ocean.si.edu

index of links

for Diving Deeper, pages 2–5 of this guide

Learn more about the dumbo octopus:
https://www.aquariumofpacific.org/onlinelearningcenter/species/dumbo_octopus

Video of a dumbo octopus: https://ocean.si.edu/ocean-life/invertebrates/dumbo-octopus-underwater-dance

Learn more about the benefits healthy oceans provide: https://oceanservice.noaa.gov/facts/why-care-about-ocean.html

U.S. energy consumption: https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T01.03#/?f=A&start=1949&end=2017&charted=1-2-3-5-12-13

Carbon footprint calculator: http://www.footprintcalculator.org

Ocean acidification: https://www.noaa.gov/resource-collections/ocean-acidification

Coral bleaching and ocean warming: https://oceanservice.noaa.gov/facts/coral_bleach.html

Oil and gas in the Gulf of Mexico:
https://www.api.org/~/media/Files/Policy/Jobs/Oil-and-Gas-2015-Economic-Impacts-Final-Cover-07-17-2017.pdf

Map of wells and rigs in the Gulf of Mexico: https://www.eia.gov/special/gulf_of_mexico/

Cold seeps: https://oceanexplorer.noaa.gov/edu/themes/cold_seeps/welcome.html

Chemosynthesis:
https://oceanexplorer.noaa.gov/okeanos/explorations/ex1711/background/chemo-comm/welcome.html

Chemosynthetic communities:
https://oceanexplorer.noaa.gov/explorations/02mexico/background/communities/communities.html

Cold seep tube worms:
https://oceanexplorer.noaa.gov/explorations/02mexico/background/tubeworms/tubeworms.html

Photosynthesis vs. chemosynthesis: https://oceanexplorer.noaa.gov/facts/photochemo.html

Chemosynthesis video: https://www.youtube.com/watch?v=BLOUFrncG7E

Deep sea corals: https://ocean.si.edu/ecosystems/coral-reefs/deep-sea-corals

Deep sea coral photos: http://ecogig.org/deepwater-corals

Deep sea coral ecology:
https://oceanexplorer.noaa.gov/explorations/06mexico/background/hardgrounds/hardgrounds.html

Bioluminescence: https://ocean.si.edu/ocean-life/fish/bioluminescence

National Geographic lessons on how humans impact the world ocean:
https://www.nationalgeographic.org/lesson/human-impacts-world-ocean/

Threats to our ocean: http://thankyouocean.org/threats/

Threats to the deep ocean: https://www.independent.co.uk/news/science/deep-sea-threats-earth-ocean-over-fishing-pollution-mining-a7741171.html

10 ways to protect the ocean: http://ecogig.org/ways-to-protect-the-ocean

ECOGIG

Gulf Ecosystem Research

ECOGIG.ORG

GULF OF MEXICO RESEARCH INITIATIVE

ZACK AND MOLLY WEB PAGE
ecogig.org/zackandmolly

ZACK AND MOLLY ON VIMEO
vimeo.com/album/5352346

ZACK AND MOLLY ON YOUTUBE
bit.ly/zackandmolly

A film by Jim Toomey

Learning Guide produced by
Sara Beresford and Emily Davenport