HMAR Teaching Guide: Marine Debris

Essential Question: What is marine debris, and how can students help prevent and manage its occurrence?

Purpose: Educate students about marine debris, general ocean conservation and threats, fishing regulations, and how to prevent marine debris from entering the environment. Hopefully, this lesson will increase student knowledge, change their attitudes, and potentially create more environmentally responsible behaviors (Torres et al., 2019). **This guide is intended to be used by teachers to gain background information on marine debris and general ocean conservation**. If the teacher would prefer, this material can be presented by a Hawaii Marine Animal Response Education and Engagement team member. Teachers can also use this teaching guide in conjunction with the HMAR Marine Debris Learning Guide to give the lesson themselves with assistance from the HMAR Education Manager if needed. **Teachers can pick and choose which pieces are most applicable to their students and can leave out whichever sections or activities they feel are unnecessary.** This guide is simply a jumping off point for a much larger topic, in this guide there are links to other resources that may be useful, but there are so many more out there as well!

Target Audience: Students in grades 5-8 in the state of Hawaii or in the mainland United States.

Objectives: By the end of this lesson, students should understand general ocean threats, including marine debris and its effect on marine life. They should also understand the positive and negative impacts they can have on marine life and marine debris. Lastly, they will learn ways they can make a difference regarding this important topic.

Prior Knowledge:

Basic prior knowledge of the ocean ecosystem, marine animals of Hawaii, and pollution, mainly focusing on marine debris, is required for this lesson. Some students may have background knowledge about fishing and net regulations from participating in those activities. However, that knowledge is not required for students to understand this lesson. Students should also have a background in general ocean conservation and potential solutions or steps that they can take personally to make a difference. For some of the introduction sections prior knowledge of wetlands and watersheds as natural filters may be helpful, as well as knowledge on invasive species. If your students have not learned about these topics before, there are links within the guide to additional resources that may help.

Instructional Method:

This lesson can be given however you want. Each section of this guide contains background information for the instructors to use to create their lectures. Each section also contains a minimum of one hands-on activity or uses critical thinking to engage the students. In addition to this teaching guide, an activity guide contains additional opportunities for engagement.

Procedures:

This Teaching Guide can be used in conjunction with the HMAR Marine Debris Learning Guide. Teachers can use this plan to gain a complete understanding of the topics discussed. This lesson contains General Ocean Conservation and Threats, Fishing Regulations and Sustainable Fishing, and the Removal and Prevention of Marine Debris. Students will be active or creative during each lesson section by combining the Activity Guide and this Teaching Guide. Before starting this lesson, please have students complete the assessment at the end of the HMAR Marine Debris Learning Guide as best they can. They may not know all the answers, and that is ok! Hopefully, they will know how to answer each question by the end of this lesson.

Lesson:

General Ocean Conservation and Threats

There are many threats to our oceans today. This guide will focus on three prevalent points when discussing marine debris and derelict fishing gear, decreasing biodiversity, and climate change.

Marine debris is a vast topic that causes many threats to our ocean ecosystem. **Marine debris** is human-created solid material that is left either intentionally or accidentally in the ocean and waterways. Marine debris is typically categorized by size, the best known being **microplastics**. Microplastics typically are created by the fragmentation of larger plastics and will continue to fragment and become smaller and smaller, never truly going away. One process that causes fragmentation is called **photo-degradation**. The problem with microplastics is that they enter the food chain very easily, eaten by fish and other animals. Because of their small size, they also make their way through natural and artificial filters and can travel large distances on currents. We will recreate a natural sediment filtration system to exemplify how microplastics move through filters and into the ecosystem and, potentially, our drinking water. *For further study – Lesson 1 of the HMAR Marine Debris Learning Guide contains a demonstration of a natural sediment filtration system.*

All sizes of marine debris can have different impacts on the ecosystem. This lesson will primarily deal with the impacts of marine debris on marine animals, either through ingestion or entanglement. At least 690 species of marine organisms have encountered marine debris, and 17% of those species were listed as near threatened or above by the IUCN Red List (Gall & Thompson, 2015). This is an issue in Hawaii since the chain of islands sits in the middle of the **North Pacific Subtropical Gyre**, which also houses the Great Pacific Garbage Patch. Why is this important? Most people think of garbage patches as giant floating islands of plastic. In reality, the plastic is spread throughout the water column from the surface to the ocean floor. The Great Pacific Garbage Patch is continually expanding and is composed of all kinds of debris, including everything from microplastics to nets and more. In a paper by Choy and Drazen in 2013, researchers studied seven species of predatory fish mainly found in the **mesopelagic** zone of the open ocean. 19% of the fishes sampled had ingested some form of marine debris (Choy & Drazen, 2013). This study solidifies this idea as these fishes live in the middle of the water column, rarely if ever coming to the surface, and they have still had opportunities to ingest marine debris. Because the debris in garbage patches is spread throughout the water column, it makes removal much more complex than simply scooping plastic off the surface.

Ingestion has multiple impacts on the individual organisms and can be deadly depending on the amount of plastic consumed (Rochman et al., 2016). One of the main reasons that

ingestion can cause death in animals is that marine debris is indigestible for the most part. This means that the objects will fill up the animal's stomach, giving them the sensation of being full (satiation) and causing them to starve. Marine debris can also cause physical harm by ripping or tearing the fragile organs and causing ruptures and internal bleeding. However, some research also details the impacts of toxins that leach from marine debris into animals' bodies. In some fish species, these chemicals have led to stress on the liver (Rochman et al., 2013).

Entanglement is another issue caused by marine debris. While ingestion has relatively similar impacts across species, entanglement tends to have more significant effects on **megafauna**. Entanglement has impacted all species of sea turtles, 66% of marine mammal species, and 50% of all seabirds (Kühn et al., 2015). Entanglement has many potential impacts on the organisms, including suffocation, limb loss, immobilization, inability to forage, and more. Most of the gear involved in entanglement is **derelict fishing gear**; these are nets, lines, and other fishing equipment left behind in the ocean, whether accidentally or on purpose. One of the best things fishers can do is to make sure that when they have finished with their line that they throw it away properly so that it does not end up in the ocean.

Marine debris can also have more nuanced impacts. One of which is that "drift debris" can carry invasive species to new locations. These invasive species significantly impact **biodiversity**, our next topic. One of the best examples of how drift debris can impact the marine ecosystem is the 2011 Japan Tsunami, which brought approximately 5 million tons of debris into the Pacific Ocean. *For further study – Lesson 2 in the HMAR Marine Debris Learning Guide contains an activity and worksheet for students to complete.* Hawaii is a biodiversity hotspot as defined by Conservation International. Part of the reason for this is that the Pacific islands have a high level of **endemism**, meaning that many species are native to those islands and are only found there. Since most flora and fauna in those ecosystems are adapted for those conditions, slight climactic changes can have significant repercussions. Invasive species are a considerable threat to biodiversity in Hawaii.

Besides invasive species, other threats to biodiversity in Hawaii include habitat loss and disease. Sea level rise will continue to negatively impact biodiversity as many of Hawaii's native seabird and sea turtle species nest and give birth on the low-lying island chain of the Papahānaumokuākea National Marine Monument. These atolls and islands could eventually disappear due to erosion, extreme weather events and high-water levels.

Many diseases also impact endemic species in Hawaii, which can come from a multitude of sources. For example, Fibropapillomatosis is a virus that impacts sea turtles, and research suggests that excess nitrogen in the water from agriculture can increase its prevalence (Herbst & Klein, 1995). Toxoplasmosis is another common disease in Hawaii, transmitted by feral cats, and can cause death in Hawaiian monk seals (Danner et al., 2007). Overall, there are many significant threats to Hawaii's biodiversity, changes to which will severely impact the functionality of the ecosystem and may lead to some species' extinction (Gurevitch & Padilla, 2004). Changes in biodiversity can have overarching implications for the rest of the species, including **trophic cascades** and potential ecosystem destruction.

We all know that our climate is changing. One of the impacts of climate change is an increase in extreme weather, such as tsunamis and hurricanes. These extreme weather events can lead to the movement of drift debris, often pushing large amounts to shore. Other than this, there is no well-studied connection between marine debris and climate change. In general, climate

change can be described as an excess of carbon dioxide in the atmosphere primarily from human causes is creating an imbalance in the environment. This imbalance causes a domino effect throughout the environment, affecting all living organisms. Some of the ecosystems that are the most impacted are in the ocean. The increase in temperature and added carbon dioxide cause acidification and a reduction in dissolved oxygen, impacting the entire food chain. The ocean is a **carbon sink**, meaning that it collects carbon dioxide out of the atmosphere and stores it; another example of a carbon sink is trees. Since the industrial revolution, the amount of carbon dioxide in the atmosphere has grown rapidly, causing an imbalance in the atmosphere and ocean. Most organisms have adapted to a particular range of pH, temperature, dissolved oxygen, and other environmental factors. Climate change and excess carbon dioxide in the atmosphere and ocean are causing widespread changes to these factors. Currently, the changes are already impacting the metabolic and growth rates of many invertebrate species. When marine organisms have excess carbon dioxide in their bloodstream over a long time, it can lead to death (Pörtner et al., 2005). Although much climate change science is dire, we are currently at a tipping point where our decisions as consumers and voters can make a difference. Solutions will be covered later on in this lesson.

Interested in talking more about general ocean threats? Below are other links to NOAA resources about biodiversity, climate change and other topics!

https://www.noaa.gov/education/resource-collections

- **https://www.noaa.gov/education/resource-collections/climate**
- **https://www.noaa.gov/education/resource-collections/ocean-coasts**
- **https://www.noaa.gov/education/resource-collections/marine-life**

https://oceanservice.noaa.gov/education/discoverclimate/
https://climate.gov/teaching

Net and Fishing Regulations, and Sustainable Fishing

In Hawaii, fishing licenses are not required for marine recreational fishing (Division of Aquatic Resources, 2019). However, some species have restrictions and regulations regarding their harvest. These rules are typically put into place to prevent overharvesting and help populations remain healthy (NC Division of Marine Fisheries, n.d.). In Hawaii, there are also regulations on net usage. Nets are a substantial resource if fishers want to catch lots of seafood in one go. However, nets are also not selective, meaning that they catch whatever is nearby, not just the intended species. This results in something called **bycatch**, unwanted fish, or other marine life caught while collecting another species. Some of the other marine life threatened by nets in Hawaii are monk seals, sea turtles, and seabirds. These threats are why there are net regulations that include checking nets every 30 minutes, thoroughly checking every 2 hours, and removing the net after 4 hours. *For further study – Lesson 2 of the HMAR Marine Debris Learning Guide contains a hands-on game for the students to participate in.*

So, why are fishing and net regulations important? Fishing regulations aim to make sure that our fish populations are not overharvested and decimated. The size restrictions are typically meant to target young fish who have not yet reached maturity. Often, fish and wildlife organizations try to reduce their harvest to reproduce and continue on the species. Seasons may be excluded due to breeding or mating seasons. Sustainable fishing is usually discussed with

commercial fisheries, the large companies collecting large amounts of fish at one time, but all people can still play a role in the sustainability of the commercial industry. Impacts can be made on the commercial industry by purchasing species that are caught in sustainable ways or have healthy and large populations.

Recreational fishing practices can be very sustainable since typically fishers are not collecting tons of fish at one time. However, there are ways that these practices can be more sustainable. One of the major impacts to marine animals from recreational as well as commercial fishing is **derelict fishing gear**, which is any type of fishing line, gear or nets left in the ocean, whether intentionally or not. Here in Hawaii the most common type of fishing line used is called **monofilament**. Although monofilament may be thin it is incredibly strong and difficult to break. Monofilament, other line, and nets can cause entanglements to our marine animals while it is floating through the water, or attached to the bottom (see page 3 of this document in *General Ocean Threats*). Derelict fishing gear can also cause problems for coral reefs by smothering them and preventing light from reaching the symbiotic **photosynthetic** algae (zooxanthellae) that live inside the coral's structure. If this smothering continues for long periods of time it could eventually lead to the death of the corals. These are just some of the reasons why it is so important to properly dispose of used line and nets so that they do not cause harm in the ocean.

Since derelict fishing gear has so many negative impacts removal from the ocean environment is necessary. There are both community-based and statewide projects dedicated to this removal in Hawaii. One of the largest missions is organized by the NOAA Pacific Islands Fisheries Science Center (PIFSC). Each year a team is assembled and travels to the Papahānaumokuākea National Monument and collects nets, line and other marine debris from the Northwestern Hawaiian Islands. In 2021 during the 30-day mission, the team collected approximately 124,000 pounds of marine debris, about 5 school buses in weight. Below are some photos from the mission (provided by NOAA).

The net regulations will hopefully prevent bycatch, as discussed earlier. Bycatch does not always have to be other types of fish but can also impact marine mammals, sea turtles, and

seabirds. In addition, bycatch does not always happen in nets; it can happen with a simple hook and line. There are specific guidelines to follow while fishing around seals and turtles to ensure those species are not caught. Most importantly, when seals and turtles appear around where people are fishing, it is best to reel in fishing lines and wait for them to pass. Fishers can also use barbless hooks to ensure that if an animal gets caught, the hook is simpler to "throw" and will take less time to rust out. Responsible boating is also an essential part of fishing around seals and turtles. Always remember to have a spotter placed on the boat's bow, and remember to drive slowly. Spotters and slow driving are a great resource to prevent striking sea turtles and other animals; these strikes can be deadly.

Discuss with the students why this information is essential. Allow for open-ended discussion with questions like:

- What did you learn in this lesson that you did not know about before?
- From your experience, why do you think sustainable fishing and consumption is important?

Removal and Prevention of Marine Debris

Now that we have gone through a few of the problems our ocean is facing, the best thing to do is discuss solutions. One of the most important aspects about teaching marine debris and general environmental threats is to make sure your students walk away with a clear understanding of how they can help and that they feel capable of taking action. In this section, we will discuss sustainable consumption, the 5 R's, and more. However, first, let us discuss the current professional efforts, mainly focusing on what HMAR does.

HMAR's work:

- In-water dives for removal: We have a specialized team of divers that travel to different parts of the island and perform underwater cleanups. They primarily focus on derelict fishing gear but will also pick up plastic, metal, or anything else they can find!
- Fishing Bins: We have large white bins made of PVC pipe at different boat harbors around the island. These bins are intended to collect used fishing line. The intention is that instead of cutting their line and throwing it away, fishers will now have a place to put the line. These bins prevent fishing lines, an entanglement hazard, from entering the ecosystem in the first place. Plus, when the line is collected, it is shipped to a manufacturer on the mainland that takes the line and recycles it to create bait fish habitats that can go under docks or piers.
- Education: Teaching students about marine debris and its impacts on our ecosystem and animals, encouraging them to help out and take action!

So, how can everyone help? Let us first talk about the prevention of marine debris, essentially how do we keep marine debris out of the ecosystem in the first place. Prevention is the best way that we can help, and is the most effective to make sure that we are not continuing this cycle of debris and trash entering the ocean.

The simplest and best way to prevent marine debris and plastic pollution is to think about the single-use and disposable items we often purchase and what we can replace them with. This is being a **sustainable consumer**. Sometimes looking at all the sustainable swaps can be

overwhelming, and some of them are downright impossible. Usually, when looking on the internet, the swaps listed are expensive and seem unrealistic. Nevertheless, there are many ways to take those seemingly expensive swaps and DIY them! For example, many people have started using "Un-paper towels," cut-up cloths with fun patterns to replace paper towels. While consumers could spend $50 for one bundle, they could also take an old shirt headed to be donated or thrown away and cut that up into small towels to clean up spills! It might not be quite as pretty, but it is an excellent solution without having to spend all that money. This idea is one of the 5 R's – reusing – a fantastic way to reduce environmental impacts. Another great way to help is by refusing or reducing the use of other products. For example, if possible, refuse the plastic straw offered at a restaurant or reduce plastic water bottles by buying a reusable one. We have already discussed the three R's – reusing, refusing, and reducing-are the best ways to be a sustainable consumer.

Recycling, the fourth R, should be used whenever possible. However, what is recyclable varies by region, so always be conscious about what is recyclable in that area and its condition. Often, people recycle objects that our area cannot recycle or materials that are contaminated; this is called *wish cycling.* Although this is done with the best intentions, typically, this contamination means that the whole batch cannot be recycled and must be thrown away. This slows down the process and the efficiency of the recycling plant as a whole. Lastly, there is rot, which entails composting vegetables and food scraps to reduce waste going to the landfill. Composting results in excellent fertilizer that can be used in gardening. *For further study – Lesson 3 of the HMAR Marine Debris Learning Guide contains an infographic and worksheet for students to complete.*

Another great way that everyone can help is by using their voice to support legislation banning single-use plastics, supporting **green fees**, or other important climate or debris-related laws. Even though middle-school students do not have the right to vote yet, they can use their voice to educate the adults in their life and later on can make a difference by voting. Taking action by voting and voicing concerns over environmental issues has a huge impact and can change the behaviors of not only individuals but corporations and governments.

Now, let us move on to removal. Lots of marine debris removal has to be done by trained professionals collecting nets and other waste from the water. However, everyone can aid in the removal of trash from land! This can be as simple as picking up trash while walking on the beach to joining a volunteer organization that participates in cleanups. Removing trash from the environment can also give people a better understanding of what is being discarded most frequently and how to limit their use of those products. Supporting organizations that participate in ocean and beach cleanups is another excellent way to help remove marine debris.
For further study – Lesson 4 of the HMAR Marine Debris Learning Guide contains multiple variations of a cleanup activity and worksheet for students to complete.

Conclusion

Congratulations! You have completed this lesson on marine debris. Although this is just the beginning, hopefully you feel more prepared to teach your students about this important topic! As a review, use the *Lesson Review* in the HMAR Marine Debris Learning Guide to have students learn a bit more about research going on worldwide relating to marine debris and how those projects influence our understanding of plastic pollution and solutions. Hopefully, your students have learned a little about general ocean threats, including marine debris, biodiversity

changes and climate shifts, net and fishing regulations as well as the removal and prevention of marine debris. Remember, educating your students about important topics like this will creating lasting impacts throughout their lives. Please have your students complete the assessment at the end of the HMAR Marine Debris Learning Guide again now that you have finished the lesson so that HMAR can understand the increase in knowledge from before to after! Thank you for your participation.

Required Vocabulary:

- Photo-degradation – the alteration of materials by light
- North Pacific Subtropical Gyre – a ring-like system of ocean currents caused by the Coriolis Effect. A place where marine debris collects, and can create garbage patches.
- Carbon sink – a natural environment that can absorb carbon dioxide from the atmosphere
- Marine Debris – Human-created solid waste that is left either intentionally or accidentally in the ocean
- Microplastics – tiny pieces of plastic debris in the environment resulting from the disposal and breakdown of consumer products and industrial waste
- Mesopelagic – (of fish and other organisms) inhabiting the intermediate depths of the sea. Approximately 650-3.300 feet below the surface
- Megafauna – animals large enough to be seen with the naked eye
- Derelict fishing gear – any discarded, lost or abandoned, fishing gear in the marine environment
- Biodiversity – the variety of life in the world or in a particular habitat or ecosystem
- Endemic Species – a species whose range is restricted to a limited geographical area
- Trophic Cascades – indirect interactions that can control entire ecosystems, occurring when a trophic level in a food web is suppressed
- Sustainable fishing – animals are harvested at a sustainable rate, where the fish population does not decline over time because of fishing practices.
- Bycatch – the unwanted species of fish and other marine animals caught while collecting the intended species.
- Monofilament -
- Photosynthetic – an organism that uses sunlight to create sugars and nutrients from carbon dioxide and water.
- Sustainable consumer – buying products that produce the least amount of waste possible for the budget and means of the person
- Wish cycling – placing something in a recycling bin with the hopes that it can be recycled
- Green fees – fee paid by visitors to support conservation initiatives

Assessments:

A quiz will be given to students before and after the lesson in order to gauge any change or growth in knowledge and understanding. These assessments are included separately and have similar questions to rethink their answers after the lesson has occurred.

Modifications:

Teachers can pick and choose as well as add any information to the lesson as they see fit. This lesson is by no means a comprehensive look at marine debris and only covers specific topics. Teachers may choose to include additional topics such as a deeper dive into the Great Pacific

Garbage Patch, watersheds, experimental design, or other solutions to the marine debris problem. If there is limited time, different sections can be complete lessons without utilizing the entire plan.

Closure:
Students participating in this lesson should have learned about the threats to our ocean ecosystem and the animals that call it home and the impacts that those threats have on humans. The end goal of this lesson is that students will know about multiple action items they can do to make a difference for our oceans.

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