Name ______________________________ Date ________________________________

Marine Ecosystems

Read the passages below. Underline any unfamiliar words or phrases.

Marine ecosystems occupy specific areas within the ocean. Some are productive near-shore regions, including estuaries, salt marshes, and mangrove forests. Others appear to be completely barren, like the ocean floor. The hydrosphere connects all freshwater and saltwater systems. The high salt content (salinity) and global circulation make marine ecosystems different from other aquatic ecosystems. Other physical factors that determine the distribution of marine ecosystems are geology, temperature, tides, light availability, and geography. Marine ecosystems include: abyssal plain (deep sea coral, whale fall, brine pool), Antarctic, Arctic, coral reef, deep sea (abyssal water column), hydrothermal vent, kelp forest, mangrove, open ocean, rocky shore, salt marsh and mudflat, and sandy shore. Some of these regions are very productive. Others are in constant darkness where photosynthesis cannot occur. Some marine ecosystems go through extreme changes in temperature, light availability, oxygen levels, and other factors on a daily basis. Others are fairly stable and only change slightly at different seasons. The organisms that inhabit marine ecosystems are as diverse as the ecosystems themselves. They must be highly adapted to the physical conditions of the ecosystems in which they live.

The **Abyssal Plain** ecosystem is one of the least explored regions of the Earth. The abyssal plain runs along the ocean floor between the base of a continental rise and a mid-ocean ridge. The abyssal plain is a harsh environment located at depths between 3,000 and 6,000 meters (10,000–20,000 feet). Little to no light reaches the abyssal plain. High pressures, extreme cold, low oxygen levels, and scarce food availability also characterize this ecosystem. Despite these harsh conditions, research has shown that the abyssal plain can include several different communities of organisms. These include deep sea corals, whale falls, and brine pools.

Deep (cold) water coral communities are distributed globally from coastal Antarctica to the Arctic Circle. They are in the bathypelagic zone and not typically found below 2,000 meters (6,600 feet). They are made up of hard corals, black and horny corals, and soft corals, including gorgonians. Like warm tropical reefs, the hard corals in deep water develop a reef structure that supports a highly diverse community of fish, crabs, urchins, and worms. Unlike warm reefs, however, they lack symbiotic algae (zooxanthellae) because they are in such deep, cold, and often dark water. This is why deep water corals are typically suspension feeders, capturing plankton and organic matter (detritus) out of the water column.

A **whale fall** community is created when a dead whale sinks and transports nutrients to the sea floor. Whale falls can exist below any waters where whales are found, especially along their migratory routes and feeding grounds. These regions tend to be along continental shelves and the deep ocean. Whale fall communities are found in the abyssopelagic zone. This zone is usually sparsely populated and minimally productive, but whale fall communities supply organic matter (up to 160 tons from one whale) and lead to the development of complex animal communities and feeding relationships. In this way, they are similar to hydrothermal vent and seep communities. After a whale falls, the first feeders (hagfish, certain crabs) are the scavengers that eat the soft tissue. Then worms, snails, and other mollusks feed on the bones and organic matter in the surrounding sediment. As bacteria increase and decompose the whale, sulfur chemicals are released and used by chemosynthetic bacteria to make organic matter. That organic matter can then be consumed for energy by other organisms. This succession of feeders and whale fall community development can last for several years.

Brine pools are areas on the seafloor (abyssopelagic zone) that have distinct surfaces and shorelines. They are like small lakes. They can form within the surrounding ocean water because of extremely high salinities that make the brine pool water much more dense than the surrounding abyssal ocean water. The more dense water sinks, forming pools on the surface of the abyssal plain. The brine pool contains high levels of methane gas that are used as chemical energy for surrounding mussel beds. The mussel beds then support communities of fish, crustaceans, and bacteria.

The **Antarctic** ecosystem of the Southern Ocean was once thought to be rather barren due to ice cover and extremely cold temperatures. Sunlight exposure in the Antarctic ranges from zero to 24 hours in a single day. These conditions make the Antarctic a harsh environment. However, research has shown that Antarctic waters are highly productive and support a diverse array of marine organisms. The Antarctic food web is the simplest on Earth and is based on one key species—krill. Krill are planktonic shrimp-like creatures. The Southern Ocean contains an estimated 500 million tons of krill. Krill is the most abundant animal in the world. Antarctica's whales, seals, penguins, albatross, petrels, fish, and squid depend on the presence of krill to support the food web. In turn, krill feed on phytoplankton and algae mats under the ice. Colder winters mean more pack ice and more algae mats. This is good for the krill when less phytoplankton is available. Without enough algae to eat, krill can die off and create a chain reaction throughout the entire food web. Researchers worry that global warming and decreasing pack ice threatens a fragile Antarctic ecosystem that is so dependent upon a single species.

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The **Arctic** ecosystem of the northern polar region is characterized by extreme seasonality of light and year-round ice cover. A diverse array of highly adapted organisms interact and thrive there. Arctic ocean species are distributed throughout the water column, within the ice, and along the seabed. Worms, copepods, bacteria, and phytoplankton live within pores and channels of the ice and at the ice-water interface. They form the base of the Arctic food web. The Arctic seafloor is comprised of numerous invertebrates, including sea stars, worms, sponges, mollusks, crabs, and anemones. In shallower depths where sunlight is available, macrophytes (large algae) are also found. Phytoplankton, copepods and other zooplankton, jellies, and fish are found in the water column between the Arctic seafloor and ice. These organisms support a number of Arctic predators, including birds, foxes, seals, and polar bears. The Arctic ecosystem contains highly adapted species and a complex food web. It is a fragile ecosystem that is vulnerable to threats from climate change, decreased ice cover, and human impacts.

Coral Reefs primarily occur throughout the warm tropical and subtropical regions of the ocean. These areas are at latitudes between the Tropic of Capricorn and Tropic of Cancer. Some corals can live in colder, deeper waters. Corals can be classified as hard (stony) or soft, and are made up of tiny animals, called polyps. Some corals contain a single polyp but most are colonial. Colonial corals contain thousands of polyps. Examples of flexible soft corals include the sea fans, sea whips, and sea plumes. True soft corals include black, mushroom, and tree corals. Stony, or reef-building, corals produce calcium carbonate skeletons and are responsible for creating the structure of the reef. Common types of stony corals include brain corals, pillar corals, plate corals, and branching corals like elkhorn and staghorn. Reef-building coral polyps divide as they grow, forming layer upon layer. Symbiotic algae (zooxanthellae) live within the tissues of reef-building corals. Some coral reefs are thousands of years old. Coral reefs are one of the most biologically diverse ecosystems in the world and are home to everything from sponges and jellies to octopus, manta rays, and sharks. They also provide spawning, nursery, refuge, and feeding areas for many marine organisms. The world's reefs contain over 4,000 different fish species and hundreds of coral species. Corals are fragile systems and their health or growth can be impacted by several factors. These factors include increased temperatures and nutrient runoff, decreased water clarity, and wave action from storms.

The **Deep Sea** (abyssal water column) ecosystem covers the vast zone of open ocean that is below 200 meters (656 feet). It includes the abyssal zone between 4,000 and 6,000 meters (13,000–20,000 feet). This ecosystem contains 98 percent of all the living space on Earth. The deep sea is a harsh environment. It is characterized by little-to-no light penetration, high pressures, extreme cold, low oxygen levels, and scarce food availability. The deep sea is less productive and populated than other marine ecosystems. The lack of light for photosynthesis results in a food web that depends on dead organisms and organic matter (detritus) sinking down from upper layers of the ocean. Several organisms are well-adapted to survive in the deep sea. In order to “see” in the dark and find food and mates, many organisms use bioluminescence (comb jellies, squid, anglerfish) or have large eyes (squid, octopus) and a strong sense of smell (fish). Many fish and invertebrates hide from predators by being black, silver, red, or translucent in color (siphonophores, jellies, mysid shrimp). Organisms that are silver or bioluminescent use their coloration to frighten or confuse predators. Their coloration also helps them communicate with species of their own kind. Many organisms have a soft, flexible body structure (siphonophore, dumbo octopus) so they can handle the high pressures of the deep sea. It is difficult to access and explore the deep sea. However, scientists believe that there are many more deep sea organisms left to be discovered.

Hydrothermal Vents are fissures (openings) in the ocean floor which release hot, mineral-rich water. This vent water can reach temperatures of up to 750° F. There are two types of hydrothermal vents. The hottest of the vents, called “black smokers,” spew a dark “smoke” composed mostly of iron and sulfide. The “white smokers” release a cooler, lighter material composed of compounds including barium, calcium, and silicon. Hydrothermal vents are found in both the Pacific and Atlantic Oceans at an average underwater depth of about 2,100 meters (7,000 feet). They are concentrated along the Mid-Ocean Ridge. The Mid-Ocean Ridge is the underwater mountain chain that winds its way around the globe. Hydrothermal vent ecosystems support familiar, yet unique and specifically-adapted life forms. Vent organisms include several species of bacteria, tubeworms, giant mussels, crabs, lobster, octopus, and even fish. Hundreds of species of animals have been identified in the hydrothermal vent ecosystems around the world. No light is available to support photosynthesis by marine algae or plants, but primary productivity occurs through chemosynthesis. This process occurs when bacteria-like organisms (archaea) turn chemical energy from the vents into useable energy. This process drives the entire hydrothermal vent food web.

Kelp Forests are coastal habitats found worldwide. They are most abundant along the rocky eastern coasts of the Pacific Ocean, from Baja California to Alaska, at depths of 2 to 27 meters (6 to 90 feet). They are often called underwater “forests” because they are layered and dominated by two canopy-forming kelp species (giant kelp and bull kelp). They also contain several understory kelp species. Kelp species are seaweeds or brown macroalgae (large algae) that prefer clear and cold, nutrient-rich waters. They can grow as much as 50 centimeters (20 inches) per day. They are one of the most productive and dynamic marine ecosystems. They provide a protected and biomass-rich habitat that supports a complex food web. Kelp forest food webs include several fish species, numerous invertebrates (snails, crabs, lobster, sea stars, sea urchins, worms), and large mammals (sea lions). Kelp forests have high levels of productivity and biomass. They are vulnerable to wave action, increased turbidity, and changes in salinity and temperature.

Mangrove ecosystems are comprised of salt-tolerant, woody mangrove trees and shrubs. They are located in shallow, low-oxygen sandy or muddy areas along shorelines. There are over 80 different species of mangrove trees throughout the tropical and subtropical zones of North and South America, Africa, the Middle East, Asia, and Oceania. The U.S. only has three species: red, black, and white mangroves. Black and white mangroves are less salt-tolerant than the red mangrove and are found farther from the water's edge. They have special adaptations to help them obtain oxygen and release excess salt. Red mangroves are the most salt-tolerant and are found closest to the water's edge. They are often submerged in shallow water with a thick, partially exposed network of roots (prop roots) that grow down from their branches. Their roots serve many important functions. They stabilize the shoreline by absorbing wave action and decreasing water flow. This allows sediments to accumulate. This prevents excess sediment and nutrients from reaching nearby seagrass and coral reef ecosystems. The prop roots also serve as a substrate (place of attachment) for numerous species of sponges, tunicates, algae, and shellfish. The mangrove forest provides a complex habitat for many ecologically and economically important organisms, including algae, sponges, barnacles, snails, mussels, crabs, fish, and birds. Many of these organisms use the mangrove for protection and feeding, and also as a nursery ground. They will then migrate to other marine ecosystems (coral reefs, open ocean, sandy shores) as adults. This makes mangrove ecosystems a vital part of maintaining fisheries within and adjacent to mangroves. Mangroves once covered vast areas of coastlines, but coastal development and pollution have destroyed significant amounts of mangrove habitat throughout the world.

Open Ocean is the largest marine ecosystem. It contains approximately 65 percent of the volume of the world ocean. It extends from the edge of the continental shelf outward and encompasses the entire water column. The open ocean zone generally refers to the upper 200 meters (656 feet) of water. This distinguishes it from the deep sea ecosystem below. It is a highly diverse and dynamic ecosystem that contains a wide variety of life. The diversity of open ocean organisms ranges from megafauna, or large animals like sharks, whales, dolphin, and sea turtles to microscopic plankton and small schooling fish. Sea birds and large migratory fish also play an important part in this ecosystem. Although the megafauna are large and seem to dominate, invertebrate species actually make up over 95 percent of the animal species found in the open ocean. Large populations of plankton drift along on ocean currents and form the base of the open ocean food web. Open ocean currents carry nutrients to different parts of the ocean. Currents also help some animals migrate and allow others to distribute their

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eggs throughout the ocean. Even though the abiotic conditions (light, temperature, salinity, circulation) of the open ocean are fairly consistent, there are areas where life is both abundant and sparse.

Rocky Shore ecosystems are coastal areas with solid rock substrate (foundation). Strong tidal influences create distinct tidal zones. Changing tides cause rocky shore areas to be completely covered with water at certain times of the day. At other times, these same areas can be completely exposed to the air (aerial exposure) and sunlight. These abiotic factors make the rocky shore one of the most physically stressful marine ecosystems. Organisms that live along the rocky shore must be able to tolerate extreme changes in temperature, salinity, moisture, and wave action. Sometimes these changes occur more than two times a day. Tidepools and rocky shores are highly complex and biologically diverse. Numerous marine invertebrates, including urchins, crabs, mussels, barnacles, anemones, sea stars, and sea hares are well-adapted to the extreme conditions of the rocky shore ecosystem. Organisms of the rocky shore face some other threats. They must also protect themselves from terrestrial species like humans, birds, cats, rodents that have access to the rocky shore.

Salt Marshes and Mudflats are low, wet, muddy areas that lie at the interface between the land and sea. They are either periodically or continuously saturated by salt water. This requires the organisms in this ecosystem to adjust to changes in water depth, salinity, and temperature. Salt marshes are characterized by salt-tolerant grasses and other low-lying plants, but no trees. They are one of the most productive ecosystems on Earth. They contain several different structural zones that form distinct habitats within the salt marsh: levees, salt pannes, pools, and mudflats. At the land-sea interface, terrestrial organisms (grasses, birds, raccoons, insects) and aquatic organisms (algae, turtles, crabs, fish) interact in complex ways within salt marshes. Salt marsh plants provide a continuous supply of dead organic matter (detritus). Bacteria decompose the detritus and help recycle it back into the system as nutrients. Marsh vegetation also provides protection and food for fish, crab, and shrimp that use the ecosystem as a nursery. Mudflats often cover low-lying areas between salt marsh vegetation, mangroves, or seagrass meadows. They form when tides or rivers deposit layers of mud (silt, clay) and nutrients (detritus). Mudflats are often associated with intertidal zones like bays, estuaries, bayous, barrier islands, and lagoons. Biodiversity in mudflats is lower than in salt marshes. Phytoplankton and zooplankton are abundant and provide food for mud snails, oysters, worms, crustaceans, and clams. Many of these animals burrow under the mud surface and filter-feed on plankton. These burrowing animals breathe through tubes to get oxygen from the surface. Fish and crabs move through the flats at high tide. Migratory birds and predatory animals visit tidal flats for feeding.

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Sandy Shores are low-lying areas of loosely deposited sand, gravel, or shells. Sandy shores are exposed between the extreme high and low tide marks. They are mostly flat. Sand dunes are exposed shoreline systems of one or more sand ridges created by the wind. Most sand on the beach comes from the weathering and decay of rocks, corals, seashells, and minerals. The surface layers of the sandy shore are always in motion from waves and wind. This makes the ecosystem unstable for many plants and animals. The organisms that inhabit the sandy shore vary according to local climate and geology. They all have special adaptations to survive in this type of environment. The ability to burrow in the sand protects them from waves and prevents them from drying out during low tide. Examples of residential sandy shore species include hermit crabs, sea urchins, sea grasses, algae, barnacles, snails, sea hares, mussels, and sea stars. Birds and turtles migrate and use sandy beaches as feeding and nesting sites. Sandy shore ecosystems play an important role in filtering seawater, cycling nutrients, and sustaining coastal fisheries. Sandy shore organisms must protect themselves from terrestrial species like humans, birds, cats, rodents that have access to them.