# EXPLORING THE TIDE ZONES OF FITZGERALD MARINE RESERVE



## How to Use This Guide

- Study the map of Fitzgerald Marine Reserve on page 2.
- Read the descriptions in this guide and study the diagrams and photos before you arrive at Fitzgerald Marine Reserve.
- Make sure your visit to the reserve will take advantage of a tide lower than 1.0 feet. You can find information about how to plan your visit on the Friends of Fitzgerald Marine Reserve website at http://www.fitzgeraldreserve.org.
- You may want to print all or part of this guide and bring it with you.

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### Fitzgerald Marine Reserve Map of Tide Zones



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# Tides and Tide Zones

Every day, twice a day, the cool waters of the Pacific ocean rise to cover the rocky reef of Fitzgerald Marine Reserve. The height of the tide depends on the alignment of the moon and sun. On some cycles even the highest tide does not cover all the sand of the reserve's beach; on other cycles waves crash against the cliffs that back the beach.

As soon as the water reaches its highest height, it begins draining away, until it reaches a low point known as low tide. Then the tide begins to rise again. This cycle happens twice each day, about twelve hours apart, as the earth rotates through the high tide bulges and low tide depressions created by the pull of the moon's gravity, as shown in the following figures. (The sun's lesser effect is ignored in these diagrams for the sake of simplicity and the figures are not drawn to scale.)



FIG 1: The pull of the moon's gravity on the ocean is the main force driving the cycle of tides.



FIG 2: The moon and other forces create two bulges in the ocean that FMR experiences as Higher High Tide and Lower High Tide. As the earth rotates, FMR moves through these bulges approximately 12 hours apart.



FIG 3: FMR experiences the tidal depressions as Lower Low Tide and Higher Low Tide.

At right is a representation of a tide table for one day. 0 represents the "still water level," or the "mean sea level." At Fitzgerald Marine Reserve, tides can vary from a high tide of almost +7 feet (reaching into The Splash Zone) to a low tide of almost –2 feet (revealing the Low Tide Zone). The Fitzgerald reefs are accessible for exploring during low tides of 1.0 foot or below. In this example, there is a high tide of +6 feet at 11:30 a.m. and a low tide of -1.0 at 5:30 p.m.



# Geologic Forces Created the Tidepools

When you step out onto the reef at the reserve, the gray and brown rocks beneath your feet are part of what geologists call the Purisima Formation. The beds of rock tilt gently towards deeper water. This rock was laid down in flat layers at the bottom of the sea between 7 million and 3 million years ago. In some places you can find fossils of animals that died while the rock was being formed, including sea shells, impressions of fish, and bones from an extinct manatee and whales.

After the sediment hardened into rock, the layers were squeezed, bent, and lifted up from the bottom of the ocean during earthquake activity. (Several large cracks in the earth called geological faults, all part of the greater San Andreas fault system, run through the reserve and out into the ocean.)

When the rocks rose above the surface of the ocean, the waves began wearing them away through erosion. As the water surges up and down with the tide, it carries sand and small pebbles that scour the reef, and may even bounce boulders and logs across the rocks in stormy conditions. The rock is siltstone, which usually is soft and crumbles easily, although in some spots the rock is harder or better protected from the waves.

The least eroded areas form the Splash Zone: the beach, the rocks right along its edge, and the lower reaches of the cliffs. Animals that live here are under water for the least amount of time. Some may only be submerged for a few hours every month.

A little farther into the tidepools are places where waves have rounded but not worn away big bulges of rock or the high edges of tilted slabs. These higher spots stick out above the surrounding reef and form the High Tide Zone. Animals that live here are able to withstand long periods of being exposed to the air.

Farther out still is the Mid Tide Zone, where rock was very hard or well-protected, and the carving waves only wore away shallow depressions. Animals that live here can cope with being uncovered by water for a short time.



Surge channel High tide zone



Farthest from the cliffs, and in some closer spots where layers of rock were softer, the waves wore away more material. The resulting long, deep cracks and deep holes from which water rarely drains away are part of the Low Tide Zone. Animals that live here need to be covered by water most of the time.

Different animals and algae have adapted to the fluctuating conditions these wave-carved zones offer, and have turned these tidepools and surge channels into their homes. The map on Page 2 and the descriptions that follow will help you explore each of these zones and meet a few organisms specially adapted to live in each.

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# Intertidal Ecology

Ecology is the study of the relationships between living things and their surroundings. At low tide, the tidepools of Fitzgerald Marine Reserve provide us with a remarkable place to study the organisms that live there.

Hundreds of species of animals and algae live on the reef. This guide concentrates on just a few organisms to help you get started learning about intertidal ecology. Descriptions of these organisms highlight the biological adaptations that plants and animals have evolved to survive in the intertidal environment.

An adaptation is a physiological or behavioral trait that an organism has evolved that works well in a specific environment. In this guide you will learn about adaptations that let certain animals survive the changing moisture, temperature, salinity, oxygen, and sunlight conditions of the intertidal environment as the tide rises and falls at Fitzgerald Marine Reserve.

This guide will let you explore the intertidal environment one zone at a time, meet a few inhabitants of each zone, and learn what adaptations make them uniquely able to survive.

# Zone 1: The Splash Zone

Zone 1 is also called The Splash Zone because during many high tide cycles it is not actually submerged—just a little sea water splashes up into some parts of the zone, which can be exposed to the air more than 75% of the time. It is only completely submerged a few days each month, and even then for a very short time.

Life in the uppermost tide zone is tolerant of temperature changes that can range 30° F in one day, and moisture that ranges from complete submersion These extreme challenges mean that there are not very many organisms adapted to live in the Splash Zone.

#### PERIWINKLE Littorina littorea

The periwinkle snail is a mollusk that thrives in The Splash Zone. Its thick shell protects it from drying out and getting too hot, and is difficult for predators like birds to break into. The periwinkle lowers its metabolism to conserve oxygen when it is not covered with seawater. It attaches itself to a crack in the rock that retains moisture when the tide goes out. The periwinkle could survive in the lower tide zones, but other snails that live there out-compete it for food and other resources. Those same snails are not well-adapted to the long periods of dryness experienced in The Splash Zone, so they do not pose a challenge to periwinkles in Zone 1.









#### FINGERED LIMPET Lottia digitalis

Limpets are mollusks with cone-shaped shells. You will find the Fingered Limpet, which has a light brown and white mottled shell with prominent ridges, in The Splash Zone. When covered by a high tide, the inch-long limpet lifts its shell and moves around to find food. The Fingered Limpet scrapes microscopic algae and freshly settled barnacles from the rock in a territory about a meter square. Another species of limpet, Lottia scabra, returns to a spot on the rock where it has made a slight depression or "home scar" that exactly matches the outline of its shell at low tide. It clamps the shell down tight against the rock, sealing water underneath, an adaptation which allows it to stay cool and breathe during low tide. Here in the Splash Zone you may find groups of limpets clustered together along a crack in the rock that retains moisture at low tide, or in cool, shady areas created by depressions in the rock. Other species of limpets are found in the lower tide zones.







Barnacle, left and Limpet

#### ACORN BARNACLE Balanus glandula

Although the 3/4-inch acorn barnacle's cone-shaped shell attached to the rock looks like a small white or light gray limpet, the animal inside is a crustacean, a family of animals that includes shrimp and crabs. A baby barnacle floats in the water as plankton. When it senses chemicals indicating that it is near a rock where other acorn barnacles live, it glues its head to that rock with glue that is twice as strong as any glue made by man. It then builds a cone-shaped fortress of limestone around its body, with a trap door in the ceiling. The trap door opens when the tide comes in, so the barnacle can feed on floating microscopic plants and animals that it kicks into its mouth with feathery legs. The trap door closes tightly

during low tide to keep water trapped inside. Acorn barnacles can survive by feeding just a few hours a month during the brief time they are covered with very high tides. You'll find other species of barnacles in the lower zones.







### Zone 2: The High Tide Zone

Zone 2 is also called the High Tide Zone. This area is covered by most high tides, but may be exposed for 35-75% of the time. Animals living here must tolerate long periods of drying out and temperatures that are much colder or hotter than the Pacific water, which here usually ranges from 50-56° F. Birds and land-based predators such as raccoons pose a hazard for the exposed reef organisms during low tides.

The incoming tide brings in food and oxygen, but in stormy weather it also may carry rocks and sticks that bang against organisms, threatening to crush or dislodge them. Although in some ways life is a little easier than in the Splash Zone, there are not many animals well-adapted to the High Tide Zone.

#### **BLACK TURBAN SNAIL** Chlorostoma (Tegula) funebralis

The most common gastropod in the intertidal regions is the black turban snail. The shell is black or dark purple but silver or white may show through where it has worn down, and the muscular foot is black on the sides. It moves slowly on its foot, but if it's attached to a sloping rock, it can

move quickly — to elude a hunting bird, octopus, or sea star, for example - by detaching and rolling down the slope. The snail can quickly withdraw into its shell, closing behind it a horny protective "door" called an operculum, sealing in water to survive low tide. You can find its cousin, the brown turban snail, in the lower tide zones, but you won't find brown and black turban snails mingling together because of their habitat preferences.

#### **HERMIT CRAB**

#### Pagurus samuelis

If, all of a sudden, one of those turban shells runs off with a wobbling gait, it is not a snail at all, but a crab that has taken over an empty snail shell. Under water, the hermit crab's long antennae stick out, and the head

and pinchers are visible as it moves about. Hermit crabs are very active, and can move from dry areas into tidepools as needed to cool themselves down, obtain oxygen, and scavenge food. When disturbed, the crab withdraws into the adopted snail shell, and you may see the crab's pinchers covering the opening much as the original snail inhabitant once used the operculum to close the opening. The hermit crab needs a supply of ever-larger empty snail shells to move into as it grows.

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map symbol

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map symbol

### Zone 3: The Mid Tide Zone

Zone 3, also known as the Mid Tide Zone, is covered by all high tides and uncovered by most low tides, so is only exposed 7-35% of the time. Dense algal growth provides ample cover for a variety of animals. Facing fewer extreme environmental challenges, more organisms live in the Mid Tide Zone than in the higher zones.



#### AGGREGATING SEA ANEMONE Anthopleura elegantissima

Anemones are relatives of corals and jellies. Anemones are round, with a mouth in the middle surrounded by feeding tentacles that both sting and hold small fish, tiny crustaceans, and anything that touches them. At low

tide these anemones pull in their tentacles and become a lump covered with bits of sand, shell, and rock. These objects probably reflect light to keep the anemone cooler and reduce water loss. The anemone's body can be up to 80 percent water; if you touch it, it will squirt the water out - probably a defensive measure to startle away a predator. But if it squirts out too much water, it may not survive to the next high tide, so PLEASE DON'T POKE THE ANEMONES!





Right: Anemones at low tide, no water in the tidepool, the anemones are covered with sand, shell and rock; above, the tide has come in and the anemones open.



#### SCULPIN Oligocottus maculosus.

The sculpin is the most common tidepool fish. Its home is small, so this fish is small—about 1 to 5 inches long, with a large head and pectoral fins. It has large gills to let it extract the maximum amount of oxygen from a tidepool as the water warms and becomes oxygen depleted during low tides. The large pectoral fins enable the fish to make quick

movements when darting to and from protected spots in the tidepool. Camouflage lets this fish blend into the background so well you may only spot it when it moves. It feeds on small crabs and shrimp, as well as smaller fish and fish eggs.





#### SEA SACS Halosaccion glandiforme

This hollow-bodied alga keeps itself filled with water so it doesn't dry out during low tides. Look closely to see a bubble of air at the top of the sac. This alga proliferates during the summer months, but winter visitors may not see this annual at all.





#### CALIFORNIA MUSSEL Mytilus californianus

As you walk out on the reef south of Cypress Point, the tough blue-black shells seen on the surf-swept top of the reef are California mussels. These clam-like animals attach themselves to the rock by strong threads called the byssus. They typically grow close together in large numbers, forming a mussel bed. They open their shells to extract nutrients and oxygen from the water during high tide. As the tide drops, they clamp their shells closed, trapping water inside to help them survive low tide.



California mussels with ochre star at upper right

#### OCHRE STAR

#### Pisaster ochraceus

Clustered together in crevices or singly in the mussel beds, where it feeds on mussels and barnacles, the ochre star is the most common star in the reserve. Most are purple or orange and have five rays (or arms), but occasionally one may be seen with a ray missing or partially grown back. Regeneration of rays, lost by accident, is a common phenomenon among sea stars. Carnivores, ochre stars are at the top of the food chain, as only rarely does anything feed on them. They have an elaborate system of tube feet that work like suction cups, driven by an internal hydraulic system filled with sea water, which is called a water vascular system.



### Zone 4: The Low Tide Zone

Zone 4, the Low Tide Zone, is only exposed for about 7% of the time, when the tide falls below zero. Here are some animals you may find if the tide is low enough during your visit.

#### GIANT GREEN ANEMONE Anthopleura xanthogrammica

This large, solitary anemone may reach a size eight inches across, and such a large anemone might be 75 years old. Like its relative the aggregating sea anemone,

which inhabits the High Tide Zone, the giant green anemone's tissues need a lot of water. Also like the smaller anemone, the giant green anemone pulls in its stinging tentacles and folds in on itself to conserve

water during low tides. As with its smaller relative, if you touch it, it will squirt water — probably a defensive measure to startle away a predator. But if it squirts out too much water, it may not survive to the next high tide, so PLEASE DON'T POKE THE ANEMONES!



For more info, including the anemone's eating habits, see Aggregating Sea Anemone on page 7.

#### RED ABALONE Haliotis rufescens

In cracks and fissures in the sub-tidal rocks lives the red abalone, its shell camouflaged with growths of algae and other marine organisms.



It sometimes ventures above the Sub-Tidal Zone to the edge of the Low Tide Zone, where you may find it partially submerged and suctioned tightly to a rock to await the incoming tide.



#### map symbol 📃

#### SEA URCHIN Strongylocentrotus purpuratus

The sea urchin is a grazing animal that eats seaweeds. Here in the reserve, this spiny round purple creature resides in holes it carves out of the soft rock in pools and along the walls of the surge channels of the Low Tide Zone. It must wait for the incoming tide to carry in scraps of seaweed, which it catches with tube feet



seaweed, which it catches with tube feet (it is a relative of the sea star) located between its movable spines. It then maneuvers this food around to its mouth, located on the underside of its body. Sea urchins living in the Sub-Tidal Zone do not make these holes, but instead crawl along the ocean floor on their tube feet and movable spines to graze on algae.

#### KELP CRAB Pugettia producta

Hidden beneath the thick layers of kelp and surf grass that grow in the Low Tide Zone lurk well-camouflaged kelp crabs. Colored like the kelp they live in (and which they also eat),



these crabs have long, spider-like legs that allow them to move quickly from one pool of water to another during low tide, which lets them stay cool and keeps them from running out of oxygen.



# Knowing No Bounds

Humans aren't the only animals that can move freely from zone to zone of the intertidal environment.

#### Birds

During your visit you may see several species of birds on the reef, such as black oystercatchers, gulls, and blue herons. They take advantage of low tides and treat the reef like a buffet bar.







Black oystercatcher



Great Blue Heron

#### **Predatory Mammals**

At night, land-based mammals such as raccoons, skunks, bobcats, and coyotes may hunt on the reef during low tide.

#### Harbor Seal Phoca vitulina

During low tide, sausage-shaped harbor seals rest on the flat-topped rocks on the outer fringe of the reserve. Ranging from gray to brown in color, some with spots, they can weigh 300 pounds, but are very shy and will swim away if people come too close. They come right up on the beach to sleep



Harbor seal and pup

during higher low tides. During the winter and spring females give birth to and nurse their young here in the reserve. If you see harbor seals, stay far back and observe them with binoculars. If you see a baby seal alone, its mother is probably out getting food. NEVER APPROACH A HARBOR SEAL PUP, you may cause it to be abandoned.



#### Red Octopus Octopus rubescens

Baby seal

One of the most amazing creatures found in the reserve's intertidal environment is the red octopus. With a golf-ball-sized body/head and eight arms that are less than a foot long, the red octopus is very at home resting beneath ledges, tucked between rocks, or lurking beneath tufts of seaweed. Although it spends most of its time submerged, it is not restricted to the Sub-Tidal Zone.

A mollusk, the octopus can swim by squirting water through a special organ called a siphon, which it directs like a jet engine. It crawls and climbs using its suckerstudded tentacles. Visitors sometimes encounter an octopus swimming in the surge channels of the Low Tide Zone, or crawling



between the pools of the Mid Tide Zone and High Tide Zone in its search for food and shelter. It's a master of camouflage and can change color, shape, and texture in the blink of an eye.

# A Few More Common Tidepool Organisms

You'll find examples of these organisms in various tide zones.

### Organism

## Description

IRIDESCENT ALGAE Iridophycus flaccidum

Bull & Whip Kelp >

Nereocystis leutkeana

By-the-Wind-Sailor *Velella velella* 



MOSSY CHITON Mopalia muscosa



BROWN PELICAN Pelecanus occidentalis

SEA PALM Postelsia palmaeformis The rainbow iridescence of this blade-like alga is caused by a layer of cells just under the surface. These cells reflect the light in this interesting way when the alga is submerged. *Iridophycus* will appear olive-green in shallow waters and red to purple when found in deeper waters.

These massive brown algae, which grow in deep water, are often seen washed up on the beach, in various states of destruction. Like most large algae, they have a "holdfast" anchored to the bottom; and the bull kelp has a long "stipe" surmounted by a gas-filled flotation bulb. The bulb keeps the wide, thin blades growing from it near the water surface, where sunlight can reach them for photosynthesis.

These deep blue hydroid colonies, only about 3 inches long, sometimes wash up on the beach in large masses. These colonies of tiny predatory creatures called polyps drift atop the ocean with tentacles hanging down below to catch plankton. On top a stiff sail catches the wind, which moves large aggregations of these relatives of jellies across vast areas of the ocean.

(Chiton is pronounced ky-ton). A flat, oval mollusc with a series of eight plates visible down its back. Several species are found in the reserve. A girdle of coarse hairs around the margin of the mossy chiton gives the animal its name. It feeds on algae.

These tough pink algae come in both branching and encrusting forms. They incorporate calcareous deposits in their tissues as they grow, which may give them protection against some algaeeating animals, although certain species of chitons and limpets consume them. The sun bleaches them white when they die.

Often seen soaring over the reef or skimming above the waves on wings that span 6 to 8 feet, this massive bird has a brown and gray body with a white head. It has a very long hooked beak with a pouch in which it traps fish. It spots fish from high in the air and folds its wings to plummet into the water to catch its prey.

This alga, which looks like a miniature palm tree, grows on the outer edge of the reef. It has adapted to the pounding of the surf in the same manner that the coconut palm survives a hurricane. Since this is an annual alga, it will only be seen on a summer day with a low tide.















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### More to Learn

While this guide emphasizes organisms that are specially adapted to live in one tide zone, many organisms you will encounter at Fitzgerald Marine Reserve can be found in two or more tide zones. The previous section introduces a few of these other organisms, but some researchers believe there are more than 400 species living in the reserve, so there is no way one short guide can mention all of them!

Scientists are still learning new information about the species we know, and even discovering new species. And every organism mentioned in this book has other fascinating traits, beyond their adaptations to particular tide zones, that you might want to learn more about. Here are a few examples:

- The giant green anemone has an alga that lives inside its tissue; the alga supplies food and oxygen for the anemone, and uses the anemone's waste products as nutrients in an interesting symbiotic relationship.
- The aggregating anemone can create a clone of itself a genetically identical individual by splitting in half, again and again and again.
- The sea urchin uses its pointy spines to dig its miniature cave in the soft rock, but it also can use those spikes to move around on the ocean floor and turn itself upright if it is ever knocked over.
- The ochre sea star pries apart the shells of a mussel and sticks its stomach down inside the shells to digest the animal inside.

You can learn more about all the organisms mentioned in this guide, and the many organisms that are not included, from the following sources:

- The World Wide Web, starting with the Friends of Fitzgerald Marine Reserve web site at http:// fitzgeraldreserve.org/
- By visiting places like the Monterey Bay Aquarium in Monterey, CA; the California Academy of Sciences in Golden Gate Park in San Francisco, CA; the Seymour Marine Discovery Center in Santa Cruz, CA; and various Visitor Centers in northern California devoted to National Marine Sanctuaries, which you can search for online
- In a variety of books and field guides, such as those listed at http://fitzgeraldreserve.org/newffmrsite/resources-recommended-reading

### Lessons in Conservation and Change

Prior to the reef at Fitzgerald Marine Reserve being designated as a marine life refuge, many people visited at low tide to harvest shellfish, fin fish, seaweeds and other organisms. They carried away mussels, sea urchins, and abalone to eat, and took buckets full of shells and sea stars to use in art projects. Fitzgerald Marine Reserve was first protected from this type of exploitation in 1969, but even then limited amounts and types of fishing were allowed.

Although shy harbor seals foraged for meals during high tides, they did not begin lingering to rest on the exposed rocks and beach until years after the passage of the federal Marine Mammal Protection Act in 1972. Over the next four decades, reserve staff and volunteers from the Friends of Fitzgerald Marine Reserve educated visitors about how to enjoy and learn from the tidepools without harming the fish and invertebrates or disturbing the harbor seals. One visible result of these conservation efforts was a gradual increase in the number of harbor seals resting on the rocks during low tide. Now dozens of seals haul out together to rest on the rocks and beach, female seals give birth to their pups in the reserve, and the population continues to grow.



Seals hauled out on the rocks

The red octopus also used to be a rarity that is now spotted regularly. The same is true of a number of nudibranchs, very colorful sea slugs. We don't know whether their perceived abundance is due to conservation efforts, environmental factors, or visitors becoming better observers. By the same token, we don't understand why some organisms that used to be common, such as the leathery brick-red foot-long gumboot chiton (*Cryptochiton stelleri*), are now less abundant.

Efforts to increase both our understanding and protection of the reef continue. In 2010, the reserve was designated a Marine Protected Area (MPA) within the Montara State Marine Reserve (SMR) under California's Marine Life Protection Act. It has the highest level of protection as a designated "no-take" area.







### Marine Protected Areas and You

Areas off the coast of California like Fitzgerald Marine Reserve are designated MPAs because they have special properties that make them good places for wildlife. Protecting an area from fishing and other types of harvesting allows the animals living there to grow and reproduce without interference from humans. These growing populations eventually "spill out" into the surrounding unprotected areas to take the place of animals being harvested, to keep our fisheries healthy.

Since the reserve has the highest level of protection, there are some strict rules you must follow when you visit, listed below. Be sure to check a tide table and plan your visit for a low tide of 1.0' or lower. Move slowly and step carefully on the reef, both for your own safety and to avoid crushing organisms underfoot. Look closely and watch patiently; often the longer you spend at one spot, the more you begin to see. Many intertidal animals are very sensitive to movement or change in light and shadow and will retreat or hide when you approach, but when you remain still they recover and go about their lives for you to observe.



- It is unlawful to injure, damage, take or possess any living, geological or cultural marine resource, except under a scientific collecting permit or authorized research, restoration, or monitoring.
- No natural materials including animals, plants, algae, shells, rocks, sand, and wood may be removed, and no fishing is permitted within Fitzgerald Marine Reserve and the larger Montara State Marine Reserve.
- Do not take buckets or nets out onto the reef and do not transfer organisms into containers, even just to observe them.
- Do not remove any life from tidepools or channels, and do not rip plants or animals from the rocks. Do not turn over rocks.
- Dogs and other pets are not permitted in Fitzgerald Marine Reserve.
- Smoking is prohibited.