

Pacific Cod (*Gadus macrocephalus*)

The line stretched out the door, and the wait was long, but the customers appeared content, chatting amongst themselves, perusing their phones, occasionally looking north towards the inland sea, only a few yards distant. It was a windless evening, and the waves lapped gently against the shore, invoking feelings of peace. Added to that was the smell of deep-fried fish and fries, turned out by the hundreds. It was a good evening for fish-and-chips. Halibut was the more expensive offering, but cod would do just as well. Flaky, white, somewhat bland-tasting fish, coated in a bready mixture, fried quickly in the small kitchen of a seaside walkup, its old, graying sign a testament to longevity and consistency. The fish was reliably good at this local restaurant. More people joined the line as the late autumn sun cast a golden glow across the bay.

Far to the north, in a colder, windier place, fishers plied the waters with nets and lines, hoping for a successful catch and participating in a regulatory system with the simple goal of maintaining a sustainable Pacific Cod fishery. It was big business, in which the unwitting fish played the most important part.

At one time roaming the North Pacific Ocean and the Salish Sea in uncountable numbers, for many years the Pacific Cod (*Gadus macrocephalus*) has provided the foundation for one of the largest fisheries on the planet. Yet prior to 1976, in the Gulf of Alaska this “groundfish” was not an important fishery. At that time the MFCMA (Magnuson Fishery Conservation and Management Act) was passed, legislation that would put into place a system for managing fisheries throughout the country. This act includes ten national standards and was reauthorized in 1996. Under this plan, the North Pacific Fishery Management Council was given authority to create and implement a Fisheries Management Plan for those species that require conservation and management. The Council is directed to take a “proactive” approach, rather than a reactive one. Among other items the FMP specifies the allowable catch methods for designated fisheries. The plan has been amended to take into consideration changing realities of the fisheries for which it is responsible. One of these is the Pacific Cod.

Fished by a variety of methods, including trawl, longline, pots, and others, by 1991 a 3,000-ton fishery and grown to over 76,000, and reached nearly 464 million pounds by 2019, a catch valued at approximately \$119 million dollars. Fished by four countries, including the United States, Canada, Russia, and Korea, by any measure the cod industry is big. At the same time, however, as commercial fishing increased exponentially in the Alaskan waters, where the largest number were taken, the four designated cod stocks continued to be considered sustainable. These “stocks” are regional, consisting of the Bering, the Gulf of Alaska, the Aleutian, and the Pacific. The Bering Sea stock is the largest, and all three are designated as “not overfished”, this in spite of the stunning declines in the second decade of the 21st century. The Pacific stock is not formally accessed.

Managed under the “Groundfish of the Gulf of Alaska Management Plan,” which covers much of the North Pacific from 3 miles offshore to a distance of 200 miles, the state of Alaska manages fishing within the three-mile state territorial waters. Such management coordinates with the federal plans when they include a species that is fished in both jurisdictions such as the Pacific Cod. Typically, there are some differences, with seasons varying and limits as well. Considered sustainable, although the take had increased significantly, the Pacific Cod commercial fishery was doing well. Then in late 2019, things went terribly wrong. The cod disappeared.

The crash was neither a surprise to fisheries biologists nor to those whose livelihood depended on a healthy cod population, and the groundfish commercial fishing community had been bracing for the closure of the fishery. On December 19, 2019, the regulators of the Pacific Cod federal fishery

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announced that there would be no 2020 cod season in the Gulf of Alaska. Regardless of the good management practices that had in theory kept in place a sustainable fishery, cod populations were at a historic low. Although such a decline could be attributed to the slow upward creep of ocean temperatures due to climate change, the blame for the crash was ultimately placed upon something very specific and hopefully, short-lived. In 2014, what came to be called the Blob anchored itself off the Pacific shoreline. And, unfortunately for humans and fish alike, it persisted.

First detected in October 2013, the oceanic Blob consisted of an area initially 500 miles (800 km) wide and 300 feet (91 meters) deep that failed to cool as it normally does in autumn. By June of 2014, the warm phenomenon had expanded to three patches, one of them in the Bering Sea. Approximately 2.5°C (4.5° F) warmer than typical, the implication for the oceanic food web was far-reaching. Food production declined dramatically, resulting in a starvation time that affected not only the fish but a wide range of other marine life. Birds that depended on the sea died by the thousands, littering the beaches; even the whales felt the loss. There simply was not enough to eat, and for the cod, the impact of the unproductive warm water was two-fold. Pacific Cod reproduction is possible only within a small, cool temperature range. The Blob was simply too warm for the annual regeneration of the northern stock. By 2015 the warm water had doubled in size, covering an area of 4 million square-kilometers from Baja California to the Aleutians.

The warm water slowly dissipated, and the eastern Pacific Ocean cooled once again, but the event was dramatic and damaging enough to offer a clue to what the future might be for so many of the species that depend on the ocean for both sustenance and as habitat for breeding and living.

With the return of more normal conditions, for the Pacific Cod and the commercial fishery that depends on it, the time of a rebound to sustainability has been difficult to predict. The crash in numbers of this species has long-range consequences, as at the very least the cod requires approximately three years to reach good fishery size. If egg laying declines as a result of unfavorable conditions, as it surely did when the Blob was so widespread and persistent, the effect may not be noticeable for a few seasons. Thus, the closure in 2020, which excluded the Bering Sea and Aleutian stock areas, may have been the beginning, not the end, of restrictions. Thus, prior to a complete shutdown, fishing restrictions had reduced the take to low numbers by 2017, declining 80 percent over four years. Recruitment of cod just wasn't happening. Yet hope remained that the fishery would revive when the Blob dissipated.

The collapse, if temporary, of the Alaskan Pacific cod fishery is significant not only in its economic impact, but in what it reveals about the effect of warming temperatures and other factors on the targeted fish. Ultimately, from a commercial point of view, it is about numbers, and those are directly tied to the life cycle requirements of Pacific Cod itself.

Research indicates that in terms of reproduction this is a very sensitive species. Pacific Cod is a long-lived groundfish, reaching a maximum age of 20 years and is known to range widely over the northern Pacific, although genetic diversity is apparently small. Although the extensive territory and at one time vast numbers of cod have supported a robust commercial fishery, with spawning so sensitive to a small temperature range of 3-6° C (37-43° F) assurance of a truly robust population is lacking. Cold is a requirement for this bottom-dwelling fish; if it warms to 7° C, recruitment of juveniles (that is, successful egg laying followed by development) is dramatically reduced.

Understanding of the ecology of the Pacific Cod, including its spawning cycle, has been the subject of research for several years and is in some respects well understood, but even biologists may have been taken by surprise when the population crashed so completely in Alaskan waters.

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Description and Evolution

Most easily recognized by its dorsal fins, of which it has three, the bottom feeding Pacific Cod ranges from depths of 12 to 549 meters (40 to 1800 feet). It is a schooling fish that likes a variety of small prey, including crabs, clams, worms, shrimp, and juvenile fish. Females begin reproduction at 4-5 years when approximately 1.6-1.9 feet in length, spawning in deep water from January to May in their home territory on the continental shelf; they are very fertile, often producing over a million eggs. The spawning adults return shallow depths when this life process is complete. Potentially large, with a record fish in the Strait tipping the scales at nearly 20 pounds while in other areas fish up to 6 feet and nearly 50 pounds

have been recorded. Also known as “gray cod,” the back is brown to grayish with dark spots and a pale belly. Below the mouth is a barbel, and the fins are edged in white. Primarily a northern fish, Pacific Cod is found from the Yellow Sea between Korea and China, north and east across the Pacific to Alaska and down the coast



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to California, where it is much less common. Considered a “species of concern” by the National Marine Fisheries Service, this much exploited, important commercial species has not been formally accessed by this agency.

Pacific Cod belongs to the Gadiformes order, a large group with approximately 75 genera, nine families, and 555 species. It is one of the few modern fish orders with an Antarctic fossil record. The fossil, dating to approximately 40 million years ago, was of a ratfish, certainly a descriptive name of a species distantly related to sharks. Origin of the order probably dates millions of years earlier, undergoing what biologists call “adaptive radiation” at the end of the Mesozoic era, about 65 years ago and best known for its big reptiles and gigantic dinosaurs. Adaptive radiation refers to the many species that can originate during a geologically relatively short time; in this case the possible mass extinction caused by the impact of an asteroid and the subsequent opening of niches for new species.

The asteroid collision, known as the K-T event, may have brought about the evolution of the Gadidae family to which the Pacific Cod belongs. It is a family with many species, including cod, haddock, whiting, and pollock, among others. These desirable fish comprise over one quarter of the commercial global catch.

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Composed of 19 species, the Gadidae family members are most easily recognized by the three dorsal fins lined up along the back. Codlike-fish of the Gadidae Family probably evolved in the northern Atlantic Ocean in shallow continental shelf waters, and it is here that the greatest number of species are found. A descendant of these eastern relatives, the Pacific Cod subsequently immigrated to the Pacific Ocean. It closely resembles the Greenland Cod (*Gadus ogac*); some researchers consider them to be the same species.

Adapted to deep as well as shallow waters, Pacific Cod forage over a wide range, and yet are less genetically diverse than Atlantic species. Thus, they are more closely related to each other, an interesting relatedness that has possible implications for their ability to recover from ocean-altering events. As researchers investigate the genetics and adaptability of cod species, the hope is that knowledge advances at a rate that can keep pace with changes and freak events, such as the Blob. It is a tall order, as there are so many organisms, including fish, that are subjected to alterations of their habitat as the planet warms. Which can survive?

And what about the Pacific Cod? If one factor, such as genetic diversity, impacts survival, the implications are far-reaching. In historic times, the Atlantic Cod population underwent a serious crash because of overfishing, yet diversity has not been lost in this species. What this implies is that such variability may promote a comeback to sustainable numbers if not the former abundance. It is an important result, but the applicability to the Pacific Cod is unknown. Answers can be difficult to determine but attempting to find and implement them has never been more pressing.

Memories of eating fish-and-chips on a cool day near a gentle sea in the company of other content customers hopefully will be renewed again and again. Yet if it means the extinction of a species that has plied the ocean for millions of years, then such memories must remain in the realm of nostalgia. Such loss is indefensible.