The Scorpaenidae: Rockfish

The gray water mirrored the morning clouds, and even the jaunty white boat appeared muted and diminished on the broad expanse of Puget Sound. The month was June, school was out, and summer officially begun, but apparently no one had informed a swirling atmosphere stuck in a pattern of early spring. Yet the sea was calm, and as long as it remained smooth the first fishing trip of the season was anticipated with a cheerfulness that offered contrast to the gloomy day.

As if in reward for venturing out, the first fish captured from the deep was of a reddish hue rather than a leaden gray. A back-and-worth movement culminated in a small splash as the sea dweller broke the surface. Now passive, the fish was accented with a few spines, a defense against more watery predators: for the anglers in the boat, it was simply a beautiful, if one to respect, facet of an other-worldly fish.

Solitary on the Sound that cold morning, we were blissfully unaware of the unsustainable takings transpiring throughout the inland sea during those halcyon days of the latter 20th century. Today we do not seek these colorful, long-lived denizens of the deep. But if we do chance to encounter one, it is a celebration, a hope for a future in which rockfish once more ply the northern seas.

With over 1,320 species, the Scorpaeniformes order is well-named, the root word “scorpion” hinting at the most well-known characteristic of at least one member family — the Scorpaenidae. With over 420 species distributed in both the Northern and Southern hemispheres, Scorpaenidae is perhaps best known for the venomous southwest Pacific stonefishes, warm saltwater dwellers that take defense to the extreme. An encounter with their spines can kill a human.

Other family members of more temperate salt waters are also armed with needle-like appendages, but these are less dangerous to those who have an unfortunate encounter. In the north Pacific, the “rockfish” are named for the habitat that many occupy; the spines of these fish serve as a warning rather than as an offensive or hunting tool. Although an encounter with a spine is painful, rockfish poison pales in comparison to the stonefishes and the lionfishes as well, another tropical group of dangerous Scorpaenidae.

Stonefish belong to the *Synanceia* genus, a small group of potentially deadly fish; the name refers to the small structures containing the poison. Most of the rockfish of the Salish Sea are members of the *Sebastes* genus, meaning “magnificent.” With at least 165 species, and apparently a group currently undergoing rapid speciation, approximately 12 rockfish species make their home in the Strait. Best known for their edibility, western Pacific rockfish were historically subjected to an unprecedented exploitation in a relatively short time. These beautiful fish essentially disappeared from the Salish Sea.

Colorful and spiky, sometimes very large, rockfish are most intriguing for their potential longevity. The oldest known rockfish lived for two centuries, and species with senescence comparable to humans are not uncommon. Size is sometimes an indicator of old age, as smaller rockfish species tend to live only a couple of decades, but the correlation is not perfect. Researchers committed to teasing out the reason for rockfish longevity have found it quite complicated.

Vivid Colors and Sharp Spines

In the northern Pacific, most fish lack the variable colors of tropical reef fishes, where bright yellows, blues, reds, accented with dark bands, spots, and other markings distinguish the many inhabitants. Salmon, herrings, sablefish, flounders, and cod — all are attractive in their own unique

ways, but none can compare to the brilliance of their southern relatives. Even spawning salmon, which forgo the blue-and-gray of most of their existence, are pale by tropical standards.

Enter the rockfish. They may not be fluorescent, but they can be very colorful, with stripes, blotches, warm tones against cool, and brightly tipped fins. Common names of fish in the Strait, such as "Canary," "Rosy," "Yellowtail," "Greenstripe," and "Redstripe," hint at the range of colors and markings. The showiest are typically bottom dwellers, while the less colorful, such as the Black Rockfish (*Sebastes melanops*) range above the floor of the sea. Other descriptive names, as with "Bocaccio," refer to form rather than color, the designation meaning "big mouth." With its massive protruding jaw, the name is definitely apt.

Then there are the spines. Penetration by a *Sebastes* needle can be quite painful, although not threatening, with swelling and infection the greatest danger. Rockfish spines are present on dorsal, pelvic, and anal fins; some are long, others short. Spines may also protrude from the head, although these appendages are not venomous.

Rockfish often have big eyes, voluminous mouths, and large heads. Adults like to eat other fish (including fellow rockfish) and crustaceans. Their teeth are typically sharp ("villiform"), intended for quick stabs. As long-lived fish, many achieve a considerable size. Canary Rockfish (*Sebastes pinniger*) measure a maximum of 30 inches (76 cm) with a potential weight of 14.7 pounds; this rockfish sometimes lives to an old age of 84 years. Several other species measure more than 20 inches, while the big Bocaccio (*Sebastes paucispinis*) reaches 36 inches (91 cm), although, interestingly, it lives only 40 years.

Oldest of all in the Strait is a rockfish of a different genus — *Sebastolobus*. Named the Shortspine Thornyhead (*Sebastolobus alascanus*), old Thornyheads have been aged at 158 years. Uncommon in the Strait, this species is also one of the deepest-dwelling rockfish, having been observed at nearly 5,000 feet (1,524 m) beneath the surface of the sea.

As the name implies, many rockfish inhabit areas of high relief, such as underwater cliffs, artificial reefs, caves, crevices, steep drop-offs, and boulder fields. Others show a preference for kelp beds or flat, gravelly, or muddy bottom terrain. Most do not swim far from their preferred habitat, although at the Canary Rockfish migrates as much as 435 miles (700 km). Some move into deep waters as they mature, but typically they live at depths less than 1,000 feet (305 m). This preferred range does not seem to be directly correlated to size as even the smallest rockfish in the Strait — the Puget Sound rockfish (*Sebastes emphaeus*) — is found in very deep waters. Site fidelity is common, unfortunate for the rockfish at times, as such home affinities have made exploitation easier.

Live Birth

Sebastes is one of the few fish genera whose large females bear live young rather than releasing eggs. Fertilization is internal, and in most species the female contributes nutrition to the developing embryo, a process known as viviparity. Juveniles reside in the water column, sometimes for an extended period depending on the species, before settling to the bottom, often in nearshore environments such as kelp beds and tide pools. Rockfish consume a variety of prey, from crustaceans to mollusks to small fish. Maturity comes quickly for some, and size is often correlated with egg production. The largest species may produce eggs numbering in the hundreds of thousands or more; most larvae will not survive.

Yet the advanced physiology of juvenile rockfish indicates one clear advantage of the live birth mechanism. Fully developed young are more positioned to cope with their environment; higher survival rates than external egg fertilization is evident. Typically, these tiny fish are not guarded, freeing the parent from all investment following birth, and within a day, most young rockfish are feeding themselves. They readily disperse, carried by currents or their own efforts and thus occupy niches newly available or previously unexplored. It is also conjectured by researchers that rapid diversification is often made possible by this reproductive method.

Live birth in fish has evolved several times but reversing back to egg laying does not occur. Other fish orders with viviparous members are the Cyprinodontiformes, an order that includes guppies, mollies, and killifish. Of the 25,000 or so named teleost species, only 500 are viviparous, and half of those are freshwater species. In *Sebastes*, the method evolved about 13 million years ago.

Newly released rockfish may be related through the mother, but paternity is more complex. Many rockfish species are polyandrous, meaning the female mates with more than one male. She might store the sperm for several months before fertilization, her body "knowing" the best time for development. For the privilege of fatherhood, males often court their mates by turning quickly, showing their tails, swimming parallel, and engaging in other displays to entice the quiet female.

Swim Bladders

Rockfish species have "closed" swim bladders, an organ that is an aid to buoyancy and depth control but hazardous to the fish if water pressure is rapidly changed. Fish brought to the surface from depths of more than 90 feet often suffer injury and behavioral alterations because of the expansion of gases inside the swim bladder. The rapidity of ascent can be swift enough to force the stomach outside of the mouth, the eyes to bulge, and damage to be inflicted on vital organs. Such fish cannot submerge. This physical reality has implications for fishing; in particular, it affects bycatch taken in commercial nets.

A possible remedy for the rapid expansion and its affect on the fish is to return the rockfish to the depth where it was caught. This correction can reverse the signs of this "barotrauma". A high percentage success rate has been revealed in studies of rockfish released in this manner.

These positive results emphasize the importance of using "descending devices" for injured rockfish. Poking a fish with a needle is not effective in balancing the pressure. Yet the question remains of how often such tools are utilized. Apparently simple devices can be made at low cost or purchased for little investment. Thus, it is possible for anglers to return rockfish to the depth at which they were caught.

In Washington state, descending devices are required for anglers targeting rockfish. Other efforts to reduce rockfish mortality, particularly as bycatch, and recommendations for fishing practices, such as targeting of non-rockfish species. How much these methods are aiding rockfish populations is not clear. Informative brochures may help; avoidance of areas where species at risk are resident is another recommendation, although one very difficult to enforce.

Fecundity and Age

Unlike the mammalian world, in which fertility declines with age, female rockfish remain very fecund, their increasing size correlated with more egg production than that of younger fish. For example, old Black Rockfish, a moderate sized species at 27 inches (69 cm), can produce 1,200,000 eggs

annually. The larger Bocaccio female carries as many as 2,298,000 eggs, while the longer-lived Canary Rockfish, a 30-inch fish, lays as many as 1,900,000 eggs.

The long lives of the females and their tendency to continue egg production, even increasing it, contributes to the stability of the population. Rockfish are not subject to a high death rate from natural causes; however, their relative slowness to mature places more importance on the older fish.

Canary Rockfish (*Sebastes pinniger*)

Unfortunately, it is precisely those fish that are much sought after by recreational and commercial anglers. Seeing a photo of a very large, hundred-year old fish caught by a happy angler, is not a particularly positive experience. These old fish make an invaluable contribution to the continuation of the species. On the other hand, re-establishment of a species is harder with long-lived fish, as delayed maturity implies slower recruitment. Recovery can take decades, if it occurs at all.

With a handful of rockfish exceeding 200 years in age, one of the oldest in the Salish Sea, although not present in the Strait, is the Rougheye Rockfish (*Sebastes aleutianus*), a species known to live 205 years. Another, the Shortraker Rockfish (*Sebastes borealis*), caught in Alaska, was aged at 200 years. Such old vertebrates are fascinating, and the question of "why" and "how" has possible implications for the study of human longevity.

It is known that rockfish inhabiting deep waters tend to live longer; the coldness at such depths seems to be a factor, possibly because of its potential effect on metabolism. Many species reach senescence at 50 years, including some medium-sized rockfish, such as the Redstripe Rockfish (*Sebastes proriger*). For shorter-lived species, maturity comes at a much younger age; an example is the Puget Sound Rockfish which can mature at two years and are highly fecund, particularly considering their size.

The correlation of age and size is evident with rockfish if not completely convincing, although scientists have long known that larger animals generally live longer. But with new genetic tools, it is possible to delve more fully into the question of old age in fishes. The rockfish seem an obvious research subject, and, in one recent study, 88 species were genetically sequenced; these represented five genera, including *Sebastes*. Several interesting findings were reported from this comprehensive study.

Among the results, the research revealed that longer-lived rockfish species possessed more genes associated with mending damaged DNA. Such species also had multiple genes involved with insulin production; these genes are similar to those in humans. It is known that regulating insulin affects

longevity in many animals — it is an important pathway in coordinating growth, homoeostasis, fertility, and other life processes.

Rockfish species also may have additional butyrophilin genes that regulate the immune system. These compounds are known to play a role in the suppression and control of inflammation. The possibility of increasing the human lifespan through greater understanding of rockfish genetics is one application of such research. As one scientist pointed out, it is the investigation of long-lived animals rather than those that live hours or days that may give insight into the relatively short lifespan, by comparison to the oldest animals, of humans.

Evolution

The *Sebastes* genus is considered a "marine species flock," meaning it is evolving rapidly, perhaps in part due to the isolating effect of internal fertilization. This method makes studying the evolutionary history challenging, and the resolution of relationships difficult. Even agreement on the number of families to which the various genera might be assigned has not been reached.

And with over 400 species worldwide, the Scorpaenidae family is indeed large. It is thought to have arisen about 55 million years ago. The *Sebastes* genus itself evolved in the middle Miocene, around 13 million years ago, with both fossil evidence and genetic studies supporting this time frame. Speciation and the expansion to new habitats are considered to have occurred through a "stepwise invasion" rather than large scale inclusion of species within a geographic region. This tendency to evolve in groups implies that sibling species tend to be in proximity. Isolation may have occurred on small scales, driven by geologically rapidly changing conditions, such as the temperature fluctuations associated with the advance and retreat of glaciers.

Studies of viviparity indicate that this reproductive method can lead to a rapid diversification of species. Gravid females may move to new niches, providing their offspring with unique opportunities. The developed young are also better equipped to deal with variable food availability, a reality of life in the North Pacific. Here, unlike the related scorpionfish of the tropics, where prey is more constant, rockfish deal with a combination of new opportunities in specialized habitats, a sedentary lifestyle (for the most part), and the seasonal ebb-and flow of resources.

Rocky Protection Lost, Overfishing, and the Decimation of a Family

Although considered delectable by those who eat them — which by the late 20th century was very many people — in the early years of the rapid growth of commercial fishing, rockfish were primarily bycatch, not targeted for sale. In their rocky habitat, many species were inaccessible to the technology of the time; others that lived on muddy sea floors were more easily caught. Eventually, advances in fishing gear that included the means to access most species made a directed fishery possible. But it was not until the 1970s that rockfish fishing really expanded and, when it did, the exploitation was breathtaking. At the time this overfishing occurred, the life cycle of the fish, was not understood. Nor was such knowledge sought, at least at first.

One reason for the increased commercial fishery interest in rockfish was the decline in salmon populations. Overfished and then subject to changing access, such as that following the Boldt decision of 1974 which decreed that the tribes were to be allowed half the catch, it was perhaps inevitable that

attention would turn other unexplored resources. The fishing community knew the rockfish were there; they simply had not been targeted.

Now low demand had become high, with winter and spring excellent times for fishing, and new gear increasing the take. And it was not only commercial fishing, both American and foreign, that began to focus on the rockfish of the eastern Pacific. Recreational fishing expanded as well, particularly near metropolitan areas, with programs in place to promote fishing. The take reached nearly 235 million tons in 1980 in central and south Puget Sound alone. During the 1980s, studies of rockfish revealed their longevity, but the awakening of regulatory response was in many ways hampered by lack of data and inconsistent surveys. It is estimated that between 1977 and 2014, rockfish declined at a rate of 3.1 to 3.8 percent a year, adding up to a maximum of a 76 percent total loss during that time. The catch peaked at nearly 400 million tons in the early 1980s.

That anglers could have such an impact on what seemed like a nearly infinite number of fish was undoubtedly unexpected (by most), and eventually, as rockfish began a decline that showed no evidence of leveling out, fishery managers began to wake up to what was now an impending crash. The rockfish simply were not there, a fact clear to both recreational and commercial fishers. It was, in a sense, simple mathematics. And no one had dealt with fish with such long lives. Recovery would be slow, and for some species, perhaps not possible at all.

Noticeable by its absence in the early years, bag limits were eventually put into place for recreational fishers. By 1983, the limit was five rockfish in the South Sound and ten in the North. "Passive management" came along in the 1990s, while commercial fishing came under more restrictive scrutiny. A Puget Sound Groundfish Management Plan was put into place in the late 1990s, and although it serves as the guideline for rockfish recovery, funding concerns are always an issue.

In 1999, a petition to list 14 rockfishes in Puget Sound as endangered or threatened evoked some response by federal agencies, but in the end only two species are listed under the auspices of the Environmental Species Act. One of those, the Bocaccio, is considered Endangered in the Salish Sea. Inexorably reaching the point most rockfish species were decimated, fishing closed in Puget Sound.

Meanwhile, scientific research has increased, and new kinds of surveys that range from SCUBA diver observations to ROV counts, have been implemented. Complex mathematical models are applied to the collected data with the goal of predicting future numbers while assessing current populations. Ultimately, regulations are implemented that reflect a multitude of concerns, from conservationist to commercial interests, to tribal and recreational alike. New fishing gear and restrictions on fishing depth are an attempt to limit incursion into rockfish habitat. Designated conservation areas, ongoing meetings, reports, surveys — all contribute to the rockfish regulatory process.

There are encouraging results for some species. In 2015, the Canary Rockfish population was declared "rebuilt" ahead of schedule; the species had been declared "overfished" in 2000. Fishing permits along the coast were changed to accommodate this reality; such new rules would affect several groundfish species. In 2018, approximately 158 metric tons of Canary Rockfish were landed in Washington state alone. This was a twenty-fold increase over 2014, when the species was still subject to more restricted fishing.

What data and practices indicate a recovery in as short a time as 15 years? Much credit is given to conservative fishing, a positive sign for engaging all involved with rockfish acquisition. The results are touted by agencies, while more cautionary opinions admit that the population is "fragile." After all, much of the recovery can be attributed to an emergency ban of commercial and recreational fishing along the west coast continental shelf in 2002. While the catch has increased since 2015, recruitment

has oscillated, and abundance, measured as egg count, has flattened. Today this number is estimated at approximately half of the historic numbers but equal to that of 50 years ago in the early 1970s.

Bocaccio's Ghosts

Along the California coast another recovery was made known in 2017 and commercial fishing of a decimated species began in earnest once again. The fish was the Bocaccio, the only Endangered fish of the Salish Sea. A million pounds (382 metric tons) were landed in offshore commercial fisheries in 2019 and another 330,000 pounds by the recreational fishery. This is a huge increase over the low count of 2000, when 25 metric tons were landed, but only about a tenth of what was being pulled from the ocean's waters in the early 1980s. That was the signal for an approaching crash. The obvious question today is whether a "recovered," long-lived species can support increased fishing.

What does this recovery mean for the Canary Rockfish, Bocaccio, and related species? The regulations are complex, the data variable, the numbers subject to error, and knowledge always incomplete. Although these two species offer an encouraging story, it is unfortunately one small chapter in an unending one, encapsulating within itself a historical reality of resource exploitation.

One of the biggest concerns with rockfish restoration remains the longevity of most species. It is difficult to plan for what may take decades to determine. Fishing limits are driven by yearly concerns and pressures, estimations and counts after the fact. It is a big arena, but it is not a game. The ability to predict the future will remain difficult, but survival of the rockfish of the Salish Sea depends on the very best attempts to address the ultimate complexity of an exploited fish family, continually on the brink.

Meanwhile, in the Salish Sea, a person must search long and widely for the chance to encounter a Bocaccio. A cooperative survey of 231 sites over the course of 73 days resulted in the finding of only three fish.

Today, while the meetings take place, the scientific papers undergo review, the conservation areas are assessed, and the many concerned and involved voices chime in, the rockfish, with their pointy snouts, big mouths, spines, and showy colors, range the seas. Long-lived like a human, those that are left release their young to an uncertain world where in the past the juveniles swam with countless companions in a sea of possibilities. Now their fate is determined by a land-locked species that in the end, is as dependent on the sea as the bright, ancient fish.