Sixgill Shark (*Hexanchus griseus*)

It was late in the day when the chartered fishing boat turned homeward from its sojourn on the wind-driven waves of the Strait. Everyone on board looked tired, the telltale signs of wind and showers in their reddened eyes and cold hands, their jovial camaraderie perhaps just a little forced. Yet in spite of the mix of exhilaration and bone-chilling fatigue, the smiles were genuine. The anglers had caught a few bottom fish, and as part of the charter fee, cleaning and preparation of the fish would be provided by the crew. What could be better? A cozy cabin, blazing logs in an old fireplace, wine, white fish, maybe some pie? Fishing wasn't a necessity for these guests, but it was a deep pleasure, the ultimate getaway, one to be anticipated each year.

Bluntnose Sixgill Shark (*Hexanchus griseus*)

As the fishers stepped onto the dock and moved towards shore, not many miles away, beneath the track of the sturdy boat, a large fish moved upwards from the deep, its substantial tail swinging slowly from side to side, its own day of fishing about to begin. It did not track prey with mechanical devices but rather with a genetically driven memory of where it must go and what it must do. For this animal, evolutionary success reduced that of the humans above to the tiniest dot on the timeline of Earth's creatures. And amongst its kind was the distinction of being the oldest, its sisters and brothers linked to a time when the origin of the dinosaurs lay in the distant future.

The ninth longest shark species in the world, this upwards-gliding monster had at one time been designated for its size and supposed sluggishness as one of the "Cow Sharks", but it resembled a cow no more than it did the human who named it, and the descriptive name of "Sixgill Shark" or "Bluntnose Sixgill Shark" at least distinguished it from all others. One of a handful of six-gilled sharks on Earth, the reason for six rather than five (the number for most sharks) may be unknown to science, but the acquisition of an extra gill or two (there are a few seven-gilled sharks) was clearly a success story. A generalist feeder, the Bluntnose Sixgill Shark (*Hexanchus griseus*) of the Salish Sea is a member of a genus basically unchanged for 60 million years.

And it is large — as fish go, very large. With a maximum length of 20 feet, sixgill sharks of 15 feet are not unknown, and females, which are heftier than males, attain an average of 12 feet. Thick and bigheaded, with a maximum weight of nearly 1300 pounds and over a thousand common enough, mass alone may enable this fish to regulate its temperature to a degree in the cold depths where it spends its days.

Even the baby sharks are large, and they are sometimes born with nearly a hundred big siblings, making this the most fecund shark in the world (not to mention the burden on the mother.) These

young are typically a couple of feet in length and as with other oviparous sharks, are nurtured with an egg yolk rather than a placenta-like structure. The female carries the developing pups for as much as two years, a long gestation period that may indicate a relatively infrequent reproductive cycle.

Sixgills are deep water sharks, with a maximum recorded depth of 8,200 feet (2,500 m), but as the sun descends, transforming their watery home into darkness, these giants sometimes swim upwards in the water column to depths of 330 feet (100 m) or less, although they more typically hunt in nighttime depths of 1,000 feet (300 m). Why do sharks, particularly the hefty Sixgill, undertake such a vertical movement (known as a diel migration)?

A thousand-pound body requires a lot of food, and even with the of buoyancy of water as an aid, such a size implies the expenditure of considerable effort for a successful hunt. Yet the big sharks are not consciously seeking maximum exertion. These giants are not the only fish moving upwards from the depths as the sun goes down. Prey that seeks the protection of the dark to pursue their own meal undertake similar ascents, sharing the space with a shark that is not particularly fussy about what it eats. Not only that, like more recently evolved sharks, this one can pull its upper lip back, protrude its teeth, and swallow its prey whole. This ability may broaden the menu, but is not necessarily the typical method, as six rows of substantial teeth on the lower jaw provide ample chewing and grinding power.

The big Bluntnose Sixgill Shark has a lot of inertia, and thus as it approaches its prey the pectoral fins are flattened, slowing its forward motion. And although continuous hunting may be necessary to nourish its body, the sixgill's size contributes to the ability to hunt in the deeper waters, where the temperature is lower and the oxygen supply much less than at the surface.

Whether vertical in search of food or horizontal in migratory movement, although it can be caught the elusive bluntnose is not particularly easy for to study. Attempts to do so have ranged from scuba forays into shallow waters in Seattle's Eliot Bay to the placement of sensing devices on deep dwelling Hawaiian sixgills. New instruments and older technologies have enabled measurements of shark acceleration and temperature, pitch and roll, movements from one deep body of water to another, including the Strait of Juan de Fuca. There are also the occasional direct observations, as with the presence of a dead, pregnant sixgill on the beach — what better way to determine if the unfortunate shark had mated with more than one male.

This desire to learn about these enigmatic, slightly scary beasts is not just a matter of scientific curiosity. Rather in part the quest (and the research money as well) is motivated by conservation concerns: it is difficult to regulate a species about which so little is known. What are its typical movements, both daily and seasonally, its preferences, and its resiliency to death? How quickly can a species that bears live young reproduce? What maximum age is typical? Where are the young? The list goes on.

Public concern over the impact of fishing on the local sixgill was most apparent in a metropolitan setting at the beginning of the 21st century. Bluntnose Sixgill sharks had been commercially taken in the past, but the shark had apparently escaped a lot of notice by anglers, and surprisingly, it was not regulated except for the limit of a maximum of 15 fish per day. Perhaps inevitably, given the size of the human population, the "discovery" of this fine fish was made, and poles and lines soon were lifting the great sharks in large numbers from the piers of Seattle's Elliot Bay. Someone was bound to notice, and in this case the "someone" was the public; in particular scuba divers who have their own specific interests in marine life. In 2001 the Washington State Department of Fish and Wildlife enacted a temporary ban on Bluntnose Sixgill Shark fishing; by 2005 the shark was given permanent protected status, at least from fishing, throughout the American part of the Salish Sea.

Research now began with observation of numbers and age. In 2003 the Seattle Aquarium undertook a three-year program that hopefully would provide some insight into sixgill presence in Elliot Bay; the study was later extended from 2008-2015. Scuba divers descended beneath the Aquarium piers, protected in a cage (although sixgills are not aggressive towards humans), and equipped with lights to permit observation in the dark waters. And bait as well. It isn't too hard to attract the eager Bluntnose Sixgill Shark.

The sharks observed in the shallow water were all subadults, and the number reported varied from 259 in the first survey to 33 in the second, a considerable difference. There was conjecture that this wide variation may have been a natural recruitment phenomenon, as sixgill shark require several years to mature. Most of the sharks were less than 9 feet in length. Additionally, although female sixgills bear more live young than other sharks, the long gestation period would be expected to affect numbers. The difference might also be explained by pier replacement at the aquarium during observations. Observation days were fewer in the second effort; however, the average was definitely less, and in fact the survey was terminated because of the lack of sharks. Yet while acknowledging that sixgill shark reproduction is not well-understood, nor is the mechanism and timing of recruitment, the sharp reduction in shark numbers can hardly be encouraging.

With the end of regular efforts to count sixgill sharks, reliance on diver's reports provided the only means for estimating numbers.

The Aquarium studies do seem to indicate that young sharks are present in more shallow waters when hunting, an important input to understanding their ecology. Determining the range, including seasonal movements of migratory habits of adult and juvenile sharks alike, involved tracking them, and acoustical surveys could provide some insight into the sixgill shark's movements. From 2006-2009 researchers monitored several sharks with acoustical arrays that included passive receivers. To conduct this survey, 70 sixgill sharks were collected between 2005 and 2008; 39 of these were tagged. All were caught in Puget Sound, in adherence to very specific regulations. Irrigated while out of the water for a maximum of 5-10 minutes, the sharks were tagged, and transmitters were imbedded near the pelvic fin.

Passive receivers were located along the coast, outer Vancouver Island and three straits, two in British Columbia, and the other the Strait of Juan de Fuca. These receivers were already part of a network laid down by city, state, federal, and native tribal agencies. Such positioning provided a rare opportunity to track the sharks. Certainly, prior to the study, it was unknown how far any individual might travel, as these deepwater fish had been most observed for up-and-down movements in the water column.

Thirty-four sharks were detected, with sixteen moving through the Strait of Juan de Fuca at some point. Most traveled during spring, only one during the fall. Presence observed by the receivers was short as the sharks moved in and out of range, with a few venturing to the outer coast, as far north as Point Reyes, California, and north to Queen Charlotte Strait, British Columbia. Some returned from these long migrations; at least one moved back and forth from the Sound to the Strait, and northward as well. The largest sharks left the region; these were mostly female, although fewer males were collected.

The length of the four-year survey did give some insight into the Bluntnose Sixgill Shark sedentary behavior and lateral movement patterns. Sedentary behavior was evident, as was the tendency to move between and beyond other locations.

The importance of the study to knowledge and conservation efforts is unquestionable. Knowing that a species exhibits both sedentary and migratory behavior indicates a local susceptibility to disturbance, such as land use changes, pollution, and fishing.

Other studies of Bluntnose Sixgill Sharks were undertaken in a subtropical location with much warmer waters — Oahu, Hawaii. Here the study of day-and-night behavior was the goal. Sixgills, as with many other sharks, are diel, meaning that on a 24-hour time period they travel from one location to another with regularity, in this case to the surface at night and to deep water during the day. The purpose of the study was not so much to determine what the sharks might prey on, but what physiological response did they have to their environment, and how rapidly did they move on the ascent or descent. Recording devices enabled measurement of intramuscular temperature, acceleration, dissolved oxygen, and depth. The prediction of reduced activity would be expected with colder water and less oxygen in such conditions.

It had been assumed that spending the days in cold water would reduce the movements, including hunting, for as the temperature dropped, so did the physiological response of the sixgill. Countering this expectation was the so-called “thermal inertia” of a shark, an idea similar to the observations of the evolution of other large animals in response to cold climates.

Various mathematical analyses provided some interesting data, much of it unexpected. Thermal inertia may indeed be a factor for this large shark, as its muscular temperature revealed a much smaller range than ambient temperature. Such a difference implied that hunting was possible during the day. The sixgill also showed a temperature “preference” in the sense that it foraged during the night at typical temperatures below 16 degrees Celsius (61° Fahrenheit). Ability to move during the day at deep water, typically around 1805 feet (550 meters), implied possible hunting activity even in low dissolved oxygen conditions. The Bluntnose Sixgill may not be as “cowlike” as believed.

All of these research efforts that contribute to knowledge of the Bluntnose Sixgill Shark may be intriguing to scientists most engaged in such pursuits, but from a conservation standpoint, the present studies and any subsequent ones are of supreme importance to preservation and possible restoration efforts. It is difficult to know how to prevent extinction of a species if knowledge is limited to fishing practices and observations alone. Too often it is too late.

And the Bluntnose Sixgill Shark was subjected to intense fishing pressure, as the inevitable collapse of the fishery indicates. In the 1920s fishing undertaken for “snow shark” (a.k.a. Sixgill), a fish with questionable palatability and a possible poisonous liver, to the 1940s when the livers were the target, in this case for the high Vitamin A content. Sharks could be worn for cover as well; a nice leather could be processed from the skin. From 1942-1946 approximately 304 tons were marketed, the end product extracted from as much as ten times the weight of the fish.

Of course, populations dropped. This is a fish with a long gestation and although numbering more than most sharks, relatively few live births. It is like logging; cut all the big trees and the forest will recover slowly, if at all. Yet the marketing of a declining fish that was obviously vulnerable was not over yet. In the 1980s to the early 1990s, once again “snow shark” was on the menu. Eventually a 90% decline in the Bluntnose SIxgill Shark in the Strait of Georgia sealed the fate of commercial endeavors for this ancient shark, and in 2011 all Canadian taking was suspended. In the United States (??

Ceasing to hunt fish now cannot guarantee the future, and sixgill population dynamics are still incomplete. Labeled a “Species of greatest Concern” by the (SGCN) under the Washington State Wildlife Action Plan (SWAP)”. And there is a biennial Cowshark Workshop symposium, begun in 2004. Diving tourists seem to like encounters with sharks, making a charter business quite successful. The worldwide distribution of this particular Cowshark could work in its favor; in particular its wide range that includes warm waters as well as cold may be beneficial.

Sixgill Shark (*Hexanchus griseus*)

Hope thus remains for a shark that goes about its business, eating, breeding, swimming, unconscious of the forces on the surface until pulled from the water by a human, for food, skin, or perhaps to be implanted with a small listening device. Few other enemies or friends impact its life. Left alone, only the availability of food, other sharks, and a deep cold sea dictate whether such an ancient creature will continue to ply the ocean's welcoming embrace.