My alarm sounds in the dark before dawn. After donning my clothes and grabbing my pack I head out of the dormitory building at Kalaloch Ranger Station on the outer coast of Olympic National Park and over to a small apartment. There I find the Park’s Coastal Monitoring crew hunched over bowls of cereal and toast. Coffee clears bleary eyes and we head to the rig by the light of headlamps. Low tide is at 7:30 a.m. and we need to be on site two hours before to allow enough time to complete our work.

In the steely blue morning twilight, we arrive at the pullout just north of the Kalaloch Beach Resort on Highway 101 and begin to unload carts from the trailer. Screaming log trucks are the only others out this early. We are here to start the coastal monitoring season at Olympic National Park. This week, we roll wagons laden with water pumps and hoses down the steep access trail to the beach for razor clam stock assessments.

The razor clam (*Siliqua patula*) resembles a geoduck more so than the familiar manila clam used in chowders and white wine-cream sauces. Longer than it is wide, its thin shell encases a meaty clam popular with recreational diggers throughout the state. There are currently five management zones along the southern 58 miles of Washington Coast. Currently, Washington Fish and Wildlife oversees four of the five which stretch from the mouth of the Columbia River north to the southern-most extent of the Quinault Indian Reservation.

The fifth and northern-most management zone sits along the southern coastal portion of Olympic National Park. This final stretch, Kalaloch Beach, is the responsibility of ONP’s Coastal Ecology crew, the same crew I find myself with this summer as the sun just peeks over the horizon casting cathedralesque shadows on the broad sandy beach.

We arrive at the survey site, a caravan of carts pushed by a half-awake crew outfitted in chest waders and dry-suits. Up ahead, Coastal Ecologist Steve Fradkin, who has scouted out our transect location, is busy marking the sampling sites with yellow flags beginning at the mean water level – the average of all tidal water levels – and extending down to the surf-line in 50-foot increments. We drop our packs well above the high-tide line, take a few last sips of coffee and head towards the surf. First order of business is to set up and prime the two-stroke Honda water pump mounted to one of our wagons.

CJ and Bill roll the cart down just in front of the surf, zip up their dry suits and begin to untangle the rigid suction hoses. They attach several sections of hose, clamp on the suction strainer – a large-holed mesh cylinder attached to the intake end of the hoses meant to keep unwanted rocks and flotsam out of the pump – and wade into the breakers.

While in the surf, the intake hose is in constant danger of being tossed onto shore. If the hose runs dry the pump will quickly overheat and seize. We have two backups on site in the trailer at all times, but it’s best to avoid destroying a $750 machine. To keep the hose in place, the intake side is fastened with a small anchor and wickets, made of bent rebar, are used to keep the hose from noodling around in the surf. If the beach had cooperated and provided a tidal lagoon, CJ and Bill wouldn’t have to stand in the breakers ensuring the hose isn’t spit back up or that the ocean eats the pump.

On the other end, Andy, Tomas and myself work to unfurl and hook up a series of PVC firehoses that stretch a few hundred feet up the beach to our first survey site. The hose is connected to a five foot “wand” constructed of PVC piping – the clam pumper’s tool of choice. A two-foot-tall, meter wide mesh cylinder is placed on top of the sand and pressurized sea water from the wand is used to liquefy the sand inside. With some gentle help the cylinder sinks into the soup and any razor clams within the perimeter float to the surface to be collected, counted and measured.

With the pump primed and chugging along, Steve gives me a primer on razor clam pumping. The trick, he tells me, is to avoid forcing the wand straight down onto the sand, instead he recommends working the wand around the cage perimeter and then into the center, making sure to liquefy the entire volume of sand within the cage.

With good pressure running, the wand is a cumbersome tool and I manage to kick up water and sand onto everyone’s waders before sending a geyser of liquefied sand straight up into our faces. Eventually, I get the feel for the work and fall into a nice rhythm. Once a hole has been liquefied, the cage is pulled back up and set one cage width away for the next hole. Repeat six times per sample locus and then bump to the next elevation taking care not to step in any freshly dug holes – the liquefied sand quickly takes on the appearance of solid ground but functions more like a pit-fall trap.

The higher elevation transects are mostly bunk. A few small juveniles, some goddess-worms (*Nephtys spp.*) writhing like snakes and mole-crabs (*Emertia analoga*) frantically trying to burrow back underground. But as we work our way down towards the surf line the number of juveniles skyrockets. Our intern Isla who is dutifully and tidily, in the way only interns can, measuring clams using a cork board and pin quickly has piles upon piles of little clams that need measuring.

Meanwhile, the surf starts to rise. Low tide is over and slack tide has passed. I take the cork board from Isla and start frantically measuring. Even working as quickly as I can, it’s a struggle to keep up with the piles of tiny juveniles being dumped at my feet. Yet, despite the piles of tiny clams there is a glaring dearth of anything over three inches in length, a fact that has lead managers to severely curtail harvest at Kalaloch since the early 2000s.

Part of this demographic pattern is tied to a massive mortality event in 1984 that resulted in the loss of over 95 percent of central Washington coast razor clams. The mass mortality led to the discovery of a bacterial pathogen known as nuclear inclusion X, or NIX for short. NIX is a *Rickettsia-*like organism and so functions like other bacterium in the *Rickettsia* genus. What this means is that NIX is an intercellular pathogen that invades the nuclei of host cells and uses them as incubators to complete their lifecycle. NIX is harmless to humans as it targets gill tissue, of which we have none, and specifically the gill tissue of razor clams. As NIX reproduces it slowly chokes out its host, eventually leading to massive ruptures in the gill tissue.

It’s unclear whether this pathogen has always affected razor clam populations but the near ubiquity – nearly 100 percent of Kalaloch Beach razor clams were infected in the summer of 2015 – and apparent high incidence of mortality among Kalaloch’s razor clam populations is uncontested. In fact, immediately after the 1984 die-off, NIX was absent from populations in Oregon and British Columbia. The prevalence, persistence and high density of NIX in Washington is an on-going mystery.

As I finish up measuring the last of the clams, the flood tide is in full swing and threatens to pull my seat – a small cooler for a sub-sample of hand dug adults for NIX monitoring – out to sea. In a frantic rush, we toss gear into wagons, uncouple hoses and scoot the pump up to higher ground. As we stack hoses and rinse sand from gear, I look at my watch, it’s only 10:30, I’m exhausted and we still have three days of sampling to go.

The days wear on and start to bleed into one another. Pre-dawn coffee, rickety wagons descending twilight trails, the mechanical thump of the pump, sore shoulders from working the wand, a fog of counting and measuring, returning to the bunkhouse to clean gear and cook brunch as most other park employees are just beginning their days. We are an odd sight, our caravan of coastal scientists. But, while we may be a passing amusement or eye-sore on the wilderness experience for park visitors, the monitoring helps paint a more comprehensive picture of Washington razor clam ecology.

Razor clams reproduce in the late spring and early summer. Male and female clams broadcast sperm and eggs into the water column where they grow into floating larva that eventually settle out onto the sand in the intertidal zone within a few weeks. While recruitment in early summer is normally followed by high mortality of young-of-the-year, it’s not uncommon for healthy adults to live for up to nine years. At Kalaloch, however, it is lucky if a clam makes it past its fifth year.

Twenty-three years of monitoring data shows that Kalaloch doesn’t necessarily have a juvenile problem - the annual surveys more-or-less consistently turn up heaps of small juvenile clams. Yet the data shows, time and time again, adult mortality ranging from 50 to 95 percent. While clam populations did recover from the mass mortality of the 80’s, they’ve never been quite the same. Decent but persistent recruitment and high adult mortality have conspired to keep Kalaloch closed to recreational harvest most years.

Kalaloch’s low and steady clam population changed in 2015 with a record shattering set of 138 million juvenile clams. To put that number in context, average juvenile recruitment along 58 miles of Washington coast is between 20-60 million. To call 2015 an anomaly is an understatement. In just roughly 5 miles of beach, over twice to seven times as many clams were recruited as would be seen over the entire coast in a single year. But by 2016, 95 percent of those clams were dead. This year, over 99 percent of that year class is gone.

With such a large number of small clams in the sand, some point to a lack of available resources as a possible explanation for the large losses seen in subsequent years. If that were the case, then one would expect these crowded juveniles to be smaller than their older brethren as growth rate in razor clams is dependent on resource availability. Yet the survey data shows a size-frequency distribution for the 2016 clams comparable to past years with fewer recruits. Increased predation from reintroduced sea otters and the ravages of winter storms no doubt put a dent in clam populations but neither adequately account for the massive losses seen in 2016.

No matter how you cut it, disease, specifically NIX remains the most compelling explanation for high clam mortality.

The numbers from this year reinforce that conclusion. By week’s end our data puts the 2017 juvenile population at 95 million – the second highest juvenile recruitment since monitoring began in 1995. However, any optimism is tempered by a second number. Adult survivorship is only around 235,000 clams, down from 7.6 million in 2016. 2017 marks the highest recorded adult mortality since the massive die-off that led to the discovery of NIX.

The record is partially the result of the abnormally large 2015 recruitment pulse – adult clam numbers jumped from just around half a million in 2015 to nearly eight million in 2016 – but it does not change the sobering fact that something is clearly wrong with the clam population at Kalaloch. A point hammered home when we return a month later to find heaps, far more than Steve can recall ever encountering, of dead and dying clams strewn along the beach. Even more puzzling, such obvious and dramatic mortality was absent in 2015.

By the end of it all, we are left scratching our heads. What explains the large pulses of juvenile clams in 2015 and 2017? Are changing ocean currents sending more larval clams north? Does increased population density exacerbate NIX related mortality? Or is there some other pathogen at work? The answers, no doubt, lie in the heaps of measured clams from future surveys. Until then, the Olympic National Park Coastal Ecology crew will patiently wait to count again with cold hands and bleary eyes in the spectral hours before morning.