Reading between the Tides

BY MARIO C. AGUILERA

Students Investigate Ecology of

Welcome to a world of extremes where inhabitants grapple daily with drastic environmental changes that impact the availability of food, shelter, and water.

It's a rough, demanding life here.

Is this the desert? Perhaps a polar region? A planet far, far away?

None of the above. The coastal intertidal zone—the area between the low and high tide lines that is not quite oceanic and not quite terrestrial—is a unique and vibrant ecosystem linking land and sea. It is vital to fresh and salt water mixing, nutrient cycling, fisheries resources, and as a food source for both migratory and resident animals. It buffers the coastal area from heavy storms and wave actions and serves an important role in trapping and transforming chemicals, trace metals, and pollutants that enter the ocean from rivers and drainage pipes. The stresses caused to the intertidal zone by both humans and nature are investigated by marine ecologists.

The inhabitants of this world are fascinating subjects to study. They must adjust to a state of perpetual change caused by fluctuations in tide levels, turbulence, oxygen, salinity, and variations brought by daily and seasonal changes and by powerful irregular events such as El Niño (see page 19).

For a variety of reasons, the intertidal zone is often overlooked by the public. Yet it is rapidly disappearing, constantly threatened by coastal development, pollution, destruction by visitors who trample fragile habitats, invasion by nonnative species, overfishing, and the effects of global climate change, including sea-level rise.

Two graduate students in the laboratory of Scripps biological oceanographer Lisa Levin are studying different types of intertidal environments.

Jana Davis's research setting is the southern California rocky shoreline, a region alternately exposed and covered with water twice a day. Low tide along the rocky shore exposes rocks, cobbles, crevices, tide pools, and caves. Drew Talley studies coastal wetland habitats, a

Opposite page, *Wetlands ecologist Drew Talley and research associate Theresa Talley perform field work at the Kendall-Frost Mission Bay Marsh Reserve.* **Above,** *Jana Davis monitors fish populations in local tide pools.*

Talley has mastered the ancient skill of cast netting to capture intertidal fishes.

complex mosaic of marsh plants, mud, and tide pools set in a network of creeks that connect and separate habitats.

"The fact that the intertidal zone seems a hideous place to live is really interesting to me," said Davis. "Some of the time, waves are crashing everywhere, and some of the time an organism is sitting in a hot, stagnant pool."

"More than 90 percent of California's coastal wetlands has been lost to human activity. I would say the wetlands are one of the most endangered habitats on Earth," said Talley. "We've dissected the links that once existed in the intertidal zone with highways and railroads. As a result, we are probably having effects on both sides of the coastal border, both inland and offshore."

Talley says that public and government awareness of the value of intertidal wetlands did not emerge until 20 years ago. Prior to this, wetlands were mainly regarded as "useless" swamps that should be replaced with "useful" developments.

TARGETING THE INTERTIDAL

Davis has evaluated how several similar fish species are all able to occupy the same general habitat, rocky intertidal tide pools. Because the intertidal zone is a heterogeneous environment, which means it encompasses many diverse factors, not all of its areas and tide pools are the same. It turns out that the fishes don't all occupy the same exact habitats. Instead, they each use slightly different types of tide pools.

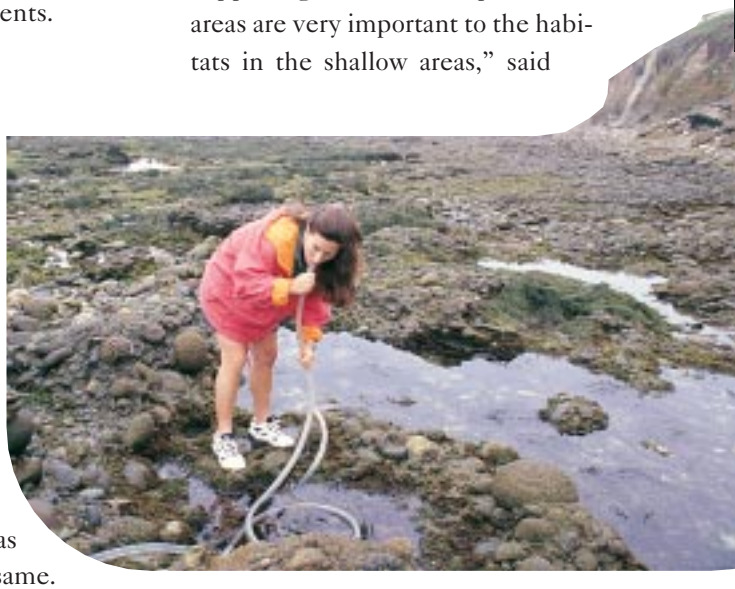
"When people see fish in a tide pool they often think that fish got trapped in there accidentally," said Davis. "They actually do it on purpose, and that surprises a lot of people.

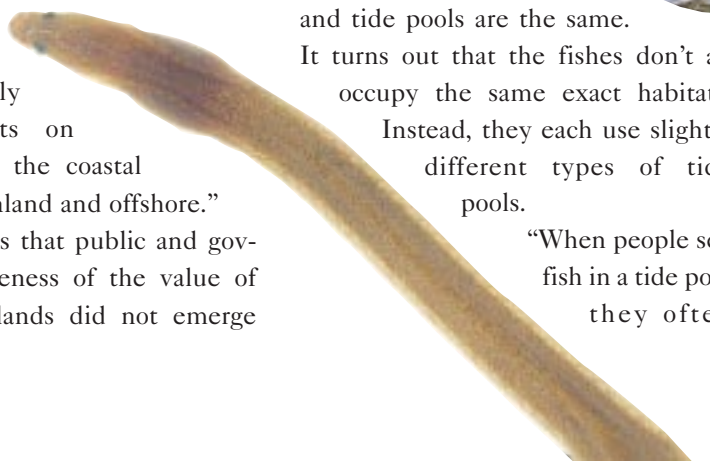
"The tricky part is figuring out how these inhabitants determine where to live in the intertidal zone."

Talley can pinpoint the exact date his thesis work took form because December 15, 1995, was the day the city of San Diego initiated a manmade wetland called the Crown Point Mitigation Site. As Talley and Scripps professor Paul Dayton watched the first tides flow into the budding wetland marsh, Talley noticed the first things to wash in were piles of algae and sea grass, not unlike "marine tumbleweeds."

That led to a discussion of colonization and how animals from remote areas travel distances by "rafting" on algae and sea grass.

"My thoughts were that events happening out in the deeper subtidal areas are very important to the habitats in the shallow areas," said





Below, *Davis siphons water from tide pools in order to isolate individual fish, which are placed in holding buckets. After measuring and determining the sex of each fish, she scoops water back into the tide pool and returns the fish to its original location.*

days, Davis's low-tech operation involves several ordinary buckets, common aquarium dip nets, plastic tubing, a hand-operated bilge pump, and a few volunteers, if she can get them.

Her objective is to analyze the inhabitants within each tide pool, documenting each fish species, size, and sex. Davis begins by displacing water from several tide pools at once, using the tubing and gravity to automatically siphon out water, similar to removing gas from an automobile fuel tank. That leaves her free to bail water out by hand from the lowest tide pools (gravity cannot be used in these tide pools due to their location).

"Most of this sampling system is about water movement and water conservation really," Davis said. "Because I have to put the water back in that I take out, I'll start with the lowest pools first. I'll drain a higher pool into a lower one, and

Talley. "The habitats are being linked together."

This became the foundation of Talley's research into linkages in the wetland environment. For his model, he chose the killifish, an animal well studied in its Atlantic Coast form but rarely studied as a Pacific Coast species, especially with regard to its habitat pattern.

"There are many factors that could affect the abundances, growth rates, and habitat decisions of fish," said Talley. "These range from avoiding predators, finding more or better food, temperature, salinity, and oxygen to something as subtle as which species of algae live in a tide pool or the density of vegetation in the wetlands."

Most of Davis's and Talley's research data have come from field work that involves long hours, tedious techniques, and unglamorous methods of observation. This type of data cultivation requires rolling up your sleeves and getting your hands dirty.

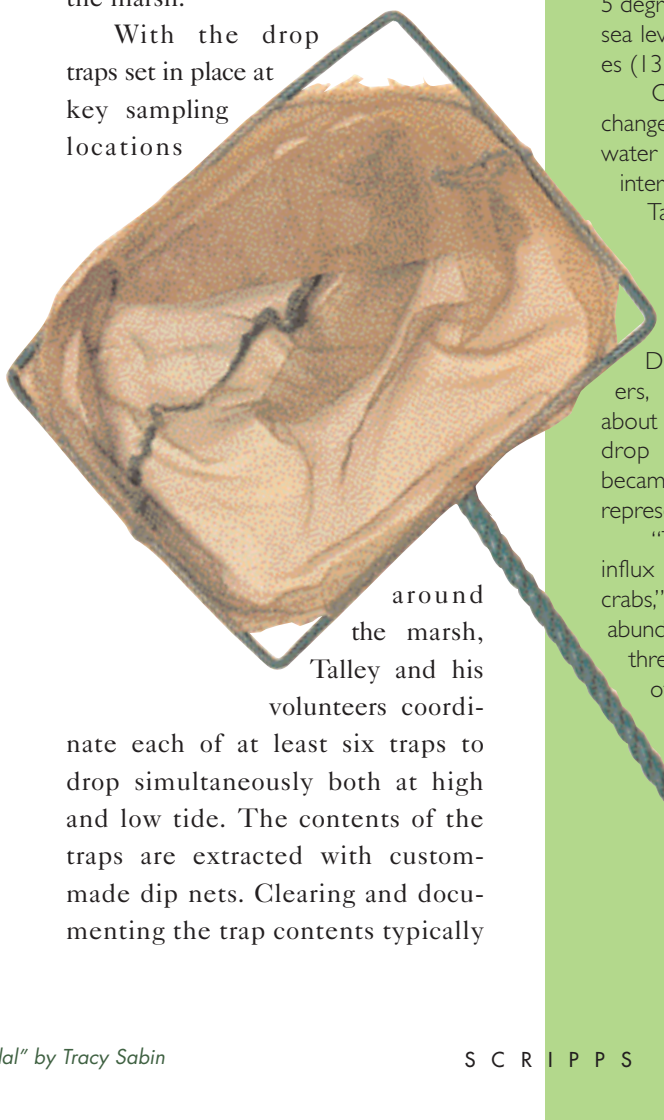
Davis has sampled a group of 100 rocky-shore tide pools for the past three and one-half years. She admits that in the beginning she simply studied the tide pools through trial and error. But after hundreds of hours on the rocky shore, her naiveté has been replaced by a clearly coordinated and effective sampling system.

Arriving before dawn on many

then replace water to the higher pool with a pool that's even higher. I keep draining one and replacing it with one higher. I always get odd looks from people walking on the beach because they see all these hoses and water all over the place."

Talley's field operation also often starts before sunrise. His sampling work is conducted through "drop traps," fish-capturing devices he adapted for the wetland marsh. The traps feature a 31-inch by 31-inch (80 cm), stainless steel box that is hoisted up to various heights and released into the water somewhat like a guillotine. The release mechanism, which is triggered by a pull cord, sits at the top of two intersecting aluminum conduits that can be adjusted up to nine feet (three meters) high to compensate for different depths of the marsh.

With the drop traps set in place at key sampling locations around the marsh, Talley and his volunteers coordinate each of at least six traps to drop simultaneously both at high and low tide. The contents of the traps are extracted with custom-made dip nets. Clearing and documenting the trap contents typically



El Nino's impact on intertidal

Because of scientific advances in computer modeling and forecasting, the 1997-1998 El Niño Southern Oscillation (ENSO) is the most researched event of its kind.

Scripps graduate students Jana Davis and Drew Talley witnessed the biological impacts of the event on the rocky shoreline and coastal wetlands of San Diego County. During the event, water temperatures increased by 5 degrees (2.8° C)on average and sea levels rose more than 5 inches (13 cm).

One of the most obvious changes was an influx of warm-water species moving into the intertidal zone. In the marsh, Talley documented an increase of bonefish, which are generally found in high abundance much further south of San Diego. Long-jawed mudsuckers, which typically represent about 10 to 15 percent of his drop trap catches, suddenly became a dominant catch, often representing 70 to 80 percent.

"There was also a huge influx of portunid [swimming] crabs," said Talley. "They were in abundances as high as two or three for every square meter of creek—it was just amazing. I regularly saw these crabs walking around with a killifish in each claw. This type of species change carries implications up and down the intertidal food web."

Among the intertidal organisms studied by Scripps marine ecologists are **Left,** *Sea hare egg mass and* **Above,** *woolly sculpin fish.*

While some factors changed, others did not. For example, intertidal fish will adjust to seasonal changes in sea level. That is, they will move to higher levels of the intertidal zone as the sea level rises in the fall. However, they did not adjust to the rising sea during the El Niño.

"It appears they just dealt with the fact that there was an increased inundation of their tide pools," said Davis.

While the number of fish in the coastal wetlands appeared to increase, the number in the rocky shoreline decreased. The typically dominant sculpin fish significantly declined during the El Niño.

Davis is now investigating the causes of the sculpin decline. While mortality of the adult sculpin was not affected, it appears sculpin were impacted during recruitment, the period in sculpin development approximately two months after the larval phase.

"The eggs begin in the tide pools, they hatch, and then the larvae go off shore," said Davis. "They are washed out to sea, and they come back in to the intertidal zone after two months. During the El Niño, it appears something bad happened to the larvae during that two-month phase. I saw few small juveniles during this time."

Davis is now analyzing the population dynamics of the sculpin to pinpoint the driving force of the El Niño impact.

"Intertidal" by Tracy Sabin

takes three hours and can yield from zero to 2,000 fish in one trap.

"My rule for documenting the contents of the traps is that we could not stop trying to scoop fish out of the trap with the net until we had made at least three full sweeps and scooped nothing out in all three," said Talley. "This doesn't sound very arduous, but in fact it was a very difficult process. The volunteers complained bitterly about this rule, and I don't blame them."

Davis and Talley have logged enough hours bailing water at the rocky shore and trudging through wetland mud that they each know their research sites intimately. They have taken the results of those long days of sampling and compiled them into computer software programs. They are analyzing the data to produce new descriptions of the rocky shore and wetland environments.

RESEARCH EXPANDS

In addition to her original curiosity about habitat distribution, Davis is studying rocky-shore population ecology. While

Above, *Talley places numerous traps in Mission Bay to help monitor fish populations.* **Left,** *The killifish is a common wetland inhabitant and study subject.*

Wetlands and tide pools require close monitoring by marine ecologists to understand natural processes and human impacts.

conducting field work, Davis noticed that certain types of tide pools appeared to be nursery areas for juveniles of some fish species. The tide pools might provide protection from predators. She is now studying the juvenile stage, including its importance to overall populations of certain fishes, such as sculpin.

"If conservation or management plans are ever established for this system or these species, it will be important to know which life stages and habitats warrant the greatest focus," said Davis.

Davis also thinks her research may help educate the public about habitat ecology in the rocky shoreline.

"From an education standpoint, the rocky intertidal is easy to get to and it draws a lot of visitors," said Davis. "So I think that this work may help when we teach students from any age group, about ecological processes and consequences of trampling the rocky-shore habitats."

Talley believes his research may have direct practical applications. In 2017, the city of San Diego plans to transform acreage on Mission Bay into a new wetland area, a project that will cost millions of dollars.

"My studies have shown that integrating intertidal pools is important in creating new wetland because fish species need shallow intertidal creek habitats and small rivulets. These findings can be applied in San Diego's new wetland area.

"I have received funding from taxpayer money, so one of the nice things about my research is it may serve a purpose by benefitting the new wetland," said Talley.