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OREGON'S AGRICULTURAL PROGRESS

Swish!

Salmon
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Ocean policy
Fish museum
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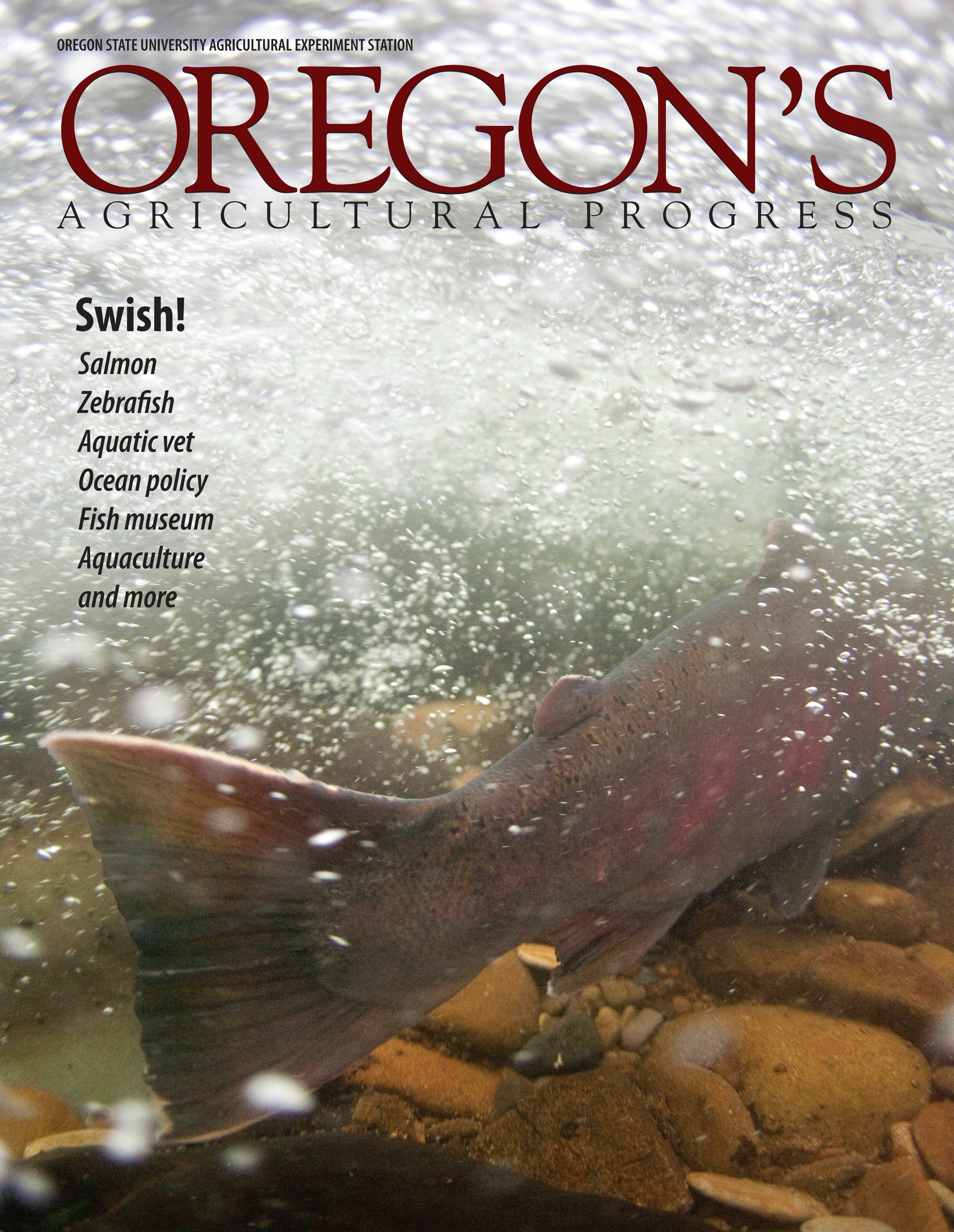

OREGON'S
AGRICULTURAL PROGRESS

WINTER 2011, VOL. 57, NO. 1, OREGON STATE UNIVERSITY

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Oregon's Agricultural Progress is published by the Oregon Agricultural Experiment Station (Sonny Ramaswamy, director). Send comments to the editor, Extension and Experiment Station Communications, OSU, 422 Kerr Admin., Corvallis, OR 97331-2119. Written material may be reprinted provided no endorsement of a commercial product is stated or implied. Please credit *Oregon's Agricultural Progress,* Oregon State University. To simplify terminology, trade names of products or equipment sometimes are used. No endorsement is intended nor is criticism implied of products not mentioned.

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Private funds, provided by the Agricultural Research Foundation, help pay for color reproduction.

Editor's Note

Fish Tales

The swish of a caudal fin through a bubbling mountain stream excites my memory.

I started my career as a fisheries biologist for the Oregon Department of Fish and Wildlife. That was at a time when fish in Oregon meant one thing: salmon. Chinook or coho, salmon were a symbol, a sport, an industry, a signature item on the menu, and—eventually—an emergency room full of endangered species. To say that salmon define the Pacific Northwest is a cautionary tale.

But fish in Oregon should mean more than salmon. There are more species of fish in the world than all the species of birds, mammals, amphibians, and reptiles *combined.* And yet there are far fewer fish in the sea than there used to be. Researchers at Oregon State University are working to restore populations of fish and to support thriving industries and livelihoods for people in Oregon and around the world. In this issue of *Oregon's Agricultural Progress* magazine, we explore ways that our future intertwines with fish.

Agricultural research is focused on solving problems and building economic opportunity—on land and water. Dive in.

Peg Herring

Coho salmon are a blur of power and speed as they migrate back to the green stream waters of Big Creek. PHOTO: Justin Bailie

HATCHING DREAMS *for a* BETTER LIFE

BY PEG HERRING

The classic fish story is about the one that got away. The modern story for many commercially important fish is that not *enough* got away. The world is running out of fish to catch. It's been estimated that stocks of some marine fish have declined by 90 percent in the last 50 years. To meet the demand for protein from a growing human population, and to take pressure off of dwindling wild stocks of fish, people are turning to fish farming.

For more than 20 years, Hillary Egna, a resource geographer at Oregon State University, has led an international program that connects U.S. scientists with researchers in developing countries around the world. The goal? To help impoverished parts of the world develop small-scale aquaculture and sustainable fisheries.

AquaFish is one of nine Collaborative Research Support Programs within USAID, the federal agency for international development. As director of the program, Egna has overseen more than 70 projects that have connected 25 U.S. land-grant universities with research partners in more than 30 host countries.

ISTOCK

Endemic to Africa, tilapia (above) is now one of the most common farmed fish in the world. At right, an undergraduate student at the Autonomous Juarez University of Tabasco, Mexico, is working with cage culture of cichlids in an educational partnership with the AquaFish Collaborative Research Support Program.

TIFFANY WOODS

It's less about fish than about poverty reduction.

AQUAFISH CRSP PHOTO

In Nicaragua, black cockles are a staple food for the poor. This local collector is helping AquaFish researchers monitor cockle populations in the Aserradores estuary.

AQUAFISH CRSP PHOTO

Small fish make a big catch for Cambodian fishermen. Local producers will use this catch to create prahoc, a fish paste used widely in southeast Asian cuisine and a food staple for the poor.

"It's less about fish than about poverty reduction," Egna said. "We work with people who work with the poor, and we help them build capacity for small-scale economic development."

There's the old saying that when you give a man a fish, he has food for a day; when you teach a man to fish, he has food for a lifetime. The AquaFish program at OSU is dedicated to that proposal. Developing countries can no longer count on foreign aid to provide their people with food and finances. It is increasingly important for these countries to establish profitable businesses that will sustain local communities. Aquaculture can provide both nourishment and employment to these countries.

Since 1980, AquaFish CRSP (and an earlier program that focused on pond aquaculture) has trained scientists around the globe, from Rwanda to Nicaragua to Vietnam. More than 800 students have been formally trained in aquaculture research and management professions. Those professionals in turn have reached more than 30,000 people through local workshops and community projects.

"This has created a huge international network of researchers and trained practitioners who share knowledge within and among host countries," Egna said. "Our partners *are* our projects. They are their countries' agents of change." By training scientists and Extension educators in their own countries, the AquaFish program builds capacity in these countries to establish and sustain industries in hatchery production, fish farming, and marketing of aquatic products.

The success of our program relies heavily on education, training, and hands-on experience.

Aquaculture has been an industry in Southeast Asia for millennia. But in parts of Africa and Latin America, it is a relatively new idea, only recently embraced by developing nations. In Kenya, for example, the national economic stimulus plan calls for 48,000 new fishponds to be built in the next two years. Such a massive investment by the Kenyan government demands knowledge in engineering, fisheries research and management, marketing, and food safety. Many of those who authored the government's aquaculture plan were educated through the AquaFish collaborative research support program, and the new ponds are being built under the supervision of AquaFish CRSP-trained Kenyan officers.

"The success of our program relies heavily on the education, training, and hands-on experience that we have received from our partnership with the AquaFish CRSP," said Godfrey Monor, Kenya's Director of Fisheries.

Most of these new ponds will be for tilapia, the most common farmed fish in the world. Unlike salmon that have a checkered reputation as farmed fish, tilapia are not top-of-the-food-chain carnivores. For the same reason that the first farmers raised sheep and not lions, most fish farmers in developing countries raise fish grazers, not predators.

Increasingly, AquaFish researchers are exploring ecosystem models with minimal impact on the surrounding environment. In the Philippines, researchers are studying production of tilapia, shrimp, oysters, and edible seaweeds in integrated ecosystems. In Mexico, AquaFish researchers are studying how to use bacteria to remove a sex-changing hormone from the water in tilapia tanks before the water is discharged into streams and lagoons.

The AquaFish program works in countries where the need is great, and where the challenges can be even greater. Research has been delayed by outbreaks of flu, wiped out by tsunamis, and destroyed by civil war. "We lost our entire operation in Rwanda during the genocides of the

AQUAFISH CRSP PHOTO

Fish farmers in China harvest rice and fish in polyculture ponds that cycle waste and nutrients in self-sustaining systems.

AQUAFISH CRSP PHOTO

In Africa, men own most of the boats. But the business of buying and selling fish is increasingly operated by women. AquaFish research focused on these micro economics to create new opportunities for African business women, such as these fish buyers in Mali.

JEFF HINO

Kenya is investing in aquaculture to feed its people and stimulate local economies. These new ponds are among 48,000 that are planned for construction by the Kenyan government in the next two years.

1990s," Egna said. "Some of our research partners were murdered; it was very, very sad."

The research that could be salvaged from Rwanda was later moved to Kenya, where aquaculture is creating new employment opportunities, especially for women. Though fishponds are owned almost exclusively by men, Kenyan women are increasingly involved in operations, including feeding, fertilization and predator control; and women now predominate in processing and marketing fish.

Increased employment for women is part of the focus of an AquaFish project in Cambodia, where research partners are developing new local markets for fish paste made from low-value small fish that would otherwise be used for animal feed. Fish paste in Southeast Asia can be compared to cheese in the U.S and Europe; it comes in many varieties and is used in many regional dishes. Expanding this niche market creates employment

We lost our entire operation in Rwanda during the genocides of the 1990s.

AQUAFISH CRSP PHOTO

The AquaFish program trains local researchers, who in turn train leaders in local communities throughout the region. At right, Dr. Charles Ngugi, an AquaFish CRSP partner in Kenya, instructs fish farmers in Mali how to calculate depth and slope of new fish ponds. Ngugi hopes that widespread aquaculture will help relieve pressure on wild stocks from overfishing in Lake Victoria (below).

JEFF HINO

for women in the manufacture and sales of these locally distinct "Cambodian cheeses." In addition, AquaFish partners in the Mekong Basin are finding ways to separate pint-size fish species from juveniles of larger, more valuable fish species to protect populations of commercially important wild fish.

The AquaFish program reaches people where and how they live, and is therefore distinctive among most other international aid programs.

AQUAFISH CRSP PHOTO

AquaFish CRSP researchers survey a fish market in Nairobi to help guide improvements in local economic development.

Most organizations see aquaculture as a positive choice.

"Most organizations see aquaculture as a positive choice," Egna said, "but they don't know how to build a system that includes environmental protection and market realities, a system that takes into consideration the microeconomics of family and community."

The AquaFish program exemplifies OSU's outreach to the global community, according to Sonny Ramaswamy, dean of the College of Agricultural Sciences. "Where people have meaningful work and enough to eat, they engage more easily in education and democracy. The AquaFish program connects research, education, and Extension in developing countries, on the ground, for the benefit of local people. It is an idea that has grown out of the land grant tradition and it works." OAP

TIFFANY WOODS

AquaFish researchers have monitored bacteria levels in Mexico's Boca de Camichin estuary to help residents know if their cultivated oysters are safe for export.

A TERN FOR THE BETTER

For the sake of fish *and* birds, Caspian terns are getting new digs across Oregon

BY MARK FLOYD

By the time a Columbia River salmon has grown from a small fry to an ocean-bound adolescent, it has spent months, sometimes years, in the fresh water of the largest river in the West. A biological signal prompts the youngster to leave behind its comfortable environs and head toward the salty waters of the Pacific Ocean, where it faces enormous physiological changes.

It's tough enough for salmon to move from fresh to marine waters where they are susceptible to a host of predators. But scientists have discovered that many of those young fish don't even make it that far. On their way to the sea, juvenile salmon must pass the world's largest nesting colony of Caspian terns. An Oregon State University study found that the terns consumed a staggering 12 million young salmon each year—roughly 10 percent of all the Columbia River basin salmon that survived to the estuary.

At Crump Lake, in the desert east of Lakeview in southern Oregon, Caspian terns share their new man-made island with gulls. Researchers have placed decoys on the island along with green speakers that broadcast a cacaphonic tern-style welcome. LYNN KETCHUM PHOTO.

To give juvenile salmon a fighting chance at survival, OSU seabird biologist Dan Roby is assisting an effort to disperse most of the large colony of terns. "Getting colonies distributed more evenly through western North America can reduce the impacts on fish—and reduce the risk of catastrophe for the birds," Roby said.

Historically these fish-loving seabirds would fly inland to nest on sandy islands in lakes from California to Canada. As human activities destroyed their nesting grounds, they began to bunch up, until most of the Pacific population of Caspian terns were centered on tiny Rice Island in the Columbia River. Rice Island was, perhaps, the "worst possible location for the world's largest Caspian tern colony," said Roby. "Terns can eat large quantities of small fish. Three-fourths of their diet was juvenile salmon and steelhead. That's not good."

Terns can eat large quantities of small fish. Three-fourths of their diet was juvenile salmon and steelhead.

After realizing the birds' heavy impact on juvenile salmon, a multi-agency team created new habitat at East Sand Island to lure the terns downstream to the mouth of the Columbia where they would find a wider variety of fish. The relocation worked better than anyone expected. The East Sand Island colony now consumes less than half as many young salmon and steelhead as the former Rice Island colony—an estimated 4 to 6 million juveniles per year. "But that's still too many," Roby said. Now the goal is to help the terns pack up and move again, dispersing most of this über-colony to multiple locations throughout the West.

For the past couple of years, Roby has worked with the Army Corps of Engineers, Bonneville Power Administration, and U.S. Fish and Wildlife Service to develop alternative nesting sites. In early 2008, engineers created a bare sand island in southern Oregon's Crump Lake.

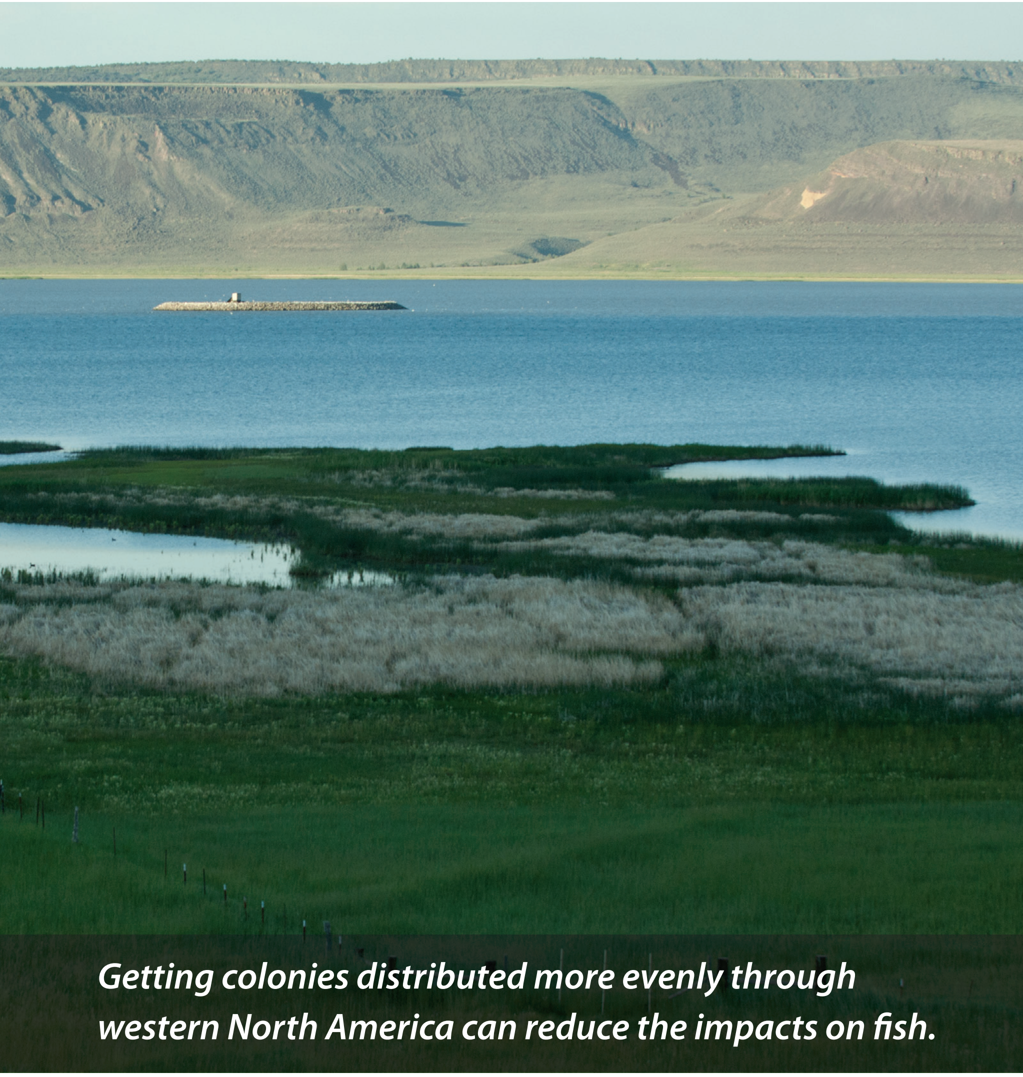
"The new island looked right," Roby said, "so we set out decoys and began broadcasting recorded sounds of nesting terns. It worked remarkably well." Five months later, more than 500 Caspian terns found their way to this inland paradise east of Lakeview, including about 430 nesting pairs. Some had leg bands indicating they had relocated from the Columbia.

The team plowed on, literally. They created an artificial island on Fern Ridge Reservoir near Eugene, a pair of islands on Summer Lake in southern Oregon, and a nearly one-acre floating island on Sheepy Lake in the Lower Klamath

LYNN KETCHUM

LYNN KETCHUM

Field technician Megan Jones (above) monitors Caspian terns at Crump Lake, while her colleague Frank Mayer (right) hauls equipment into the researchers' blind. The U.S. Army Corps of Engineers created the island to help disperse Caspian terns across their historical range. Far away from migrating young salmon, the terns at Crump Lake feed primarily on small tui chub, bullhead catfish, and crappie.



Getting colonies distributed more evenly through western North America can reduce the impacts on fish.

LYNN KETCHUM

LYNN KETCHUM

National Wildlife Refuge. Roby and his colleagues eagerly awaited 2010 to see how many Caspian terns would establish themselves at the new sites, and whether birds from East Sand Island would be among them.

Then nature intervened.

Drought conditions, El Nino, and a late, cold spring led to horrendous conditions for most seabirds throughout the Northwest. "The terns nested late, with little to eat. It was, perhaps, the worst nesting year since we began monitoring," Roby said.

At Crump Lake, just a handful of terns nested, and the few chicks that hatched were quickly devoured by California gulls. The two islands in Summer Lake didn't fare much better. Even East Sand Island, still home to the world's largest Caspian tern colony, logged the worst nesting year in its recorded history.

"Caspian terns fare best when there is upwelling from January through March, and ocean productivity gets off to a good start," Roby said. "Then they come into the breeding season in good shape. It's also good to have a deep snowpack, followed by a warm spring to encourage inland sources of food. None of those things happened this year; it was something of a disaster."

The birds may have some kind of 'populational memory' that brings them back in times of stress.

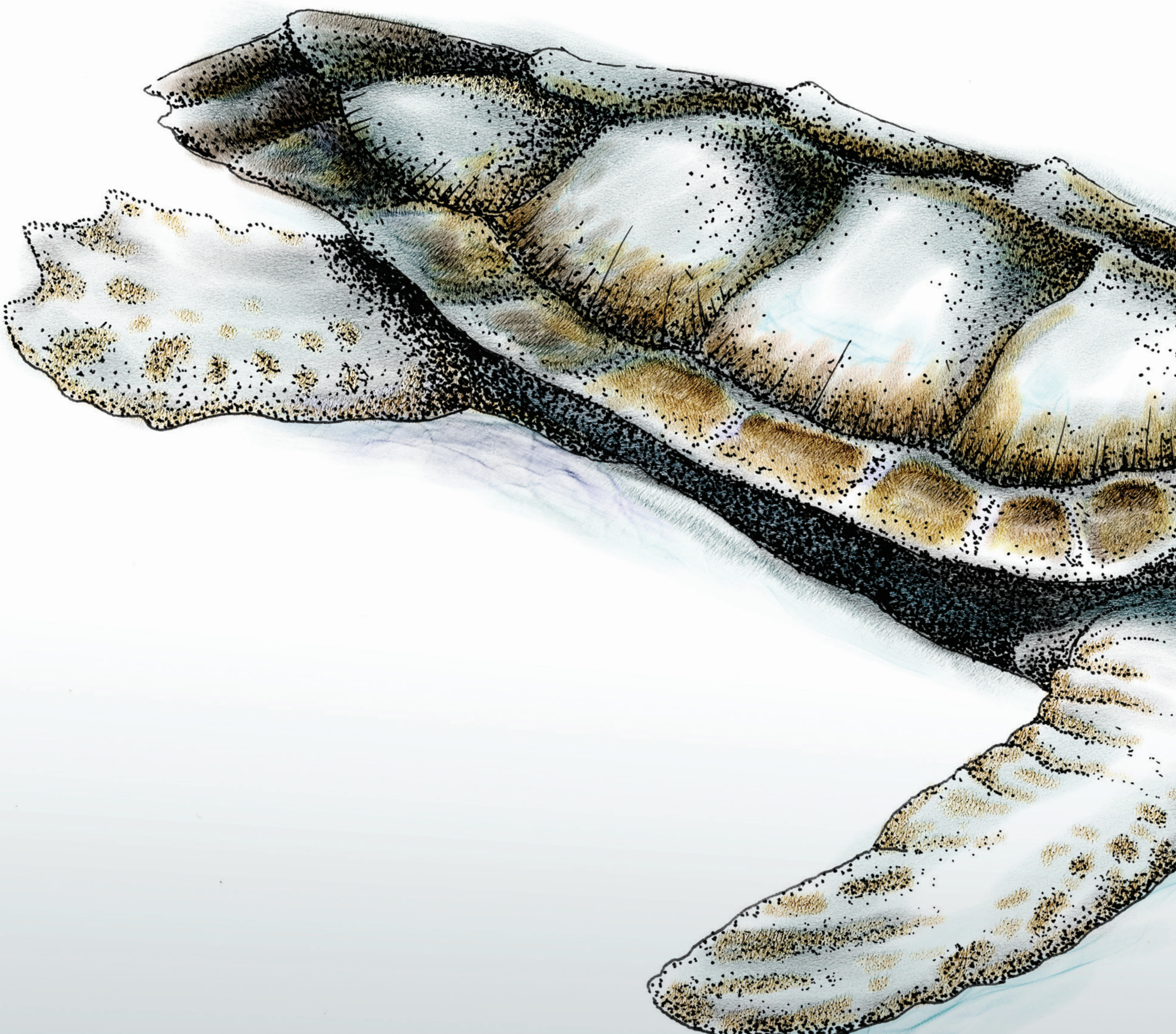
Except at the new floating island on Sheepy Lake. There, 258 pairs of Caspian terns enjoyed a higher nesting success rate than any other colony in the Pacific Northwest. In addition, two new colonies, each with about 200 nesting pairs, appeared in south-central Alaska; among them were a number of bands identifying them as Oregon birds. Roby is intrigued how they found their way north to new sites. "The birds may have some kind of 'populational memory' that brings them back in times of stress," Roby speculated. "It's an interesting question."

Though disappointed with the 2010 nesting season, project leaders are encouraged by their ability to create new habitat and lure birds in to nest. Their success has drawn the interest of resource managers in China, where the government is in a race to save the Chinese crested tern, one of the most critically endangered bird species on Earth. The total population is estimated to be less that 50. Like their Caspian cousins, Chinese crested terns nest on islands; the few remaining birds are located on one or two small islands in the Strait of Taiwan.

Earlier this year, Roby gave a presentation in China on Caspian terns. He was immediately sought out by Chinese officials who would like to create new habitat for the crested terns. Roby soon found himself working with resource managers from China, Taiwan, and Japan. "Despite strained relationships among these countries, everyone was working together to save this endangered bird species and learn from our experiences with Caspian terns," Roby said.

It could be that relocating terns to protect salmon will have unexpected rewards beyond the Columbia River. OAP

WADING INTO THE DEPTHS



OF OCEAN POLICY

BY PEG HERRING

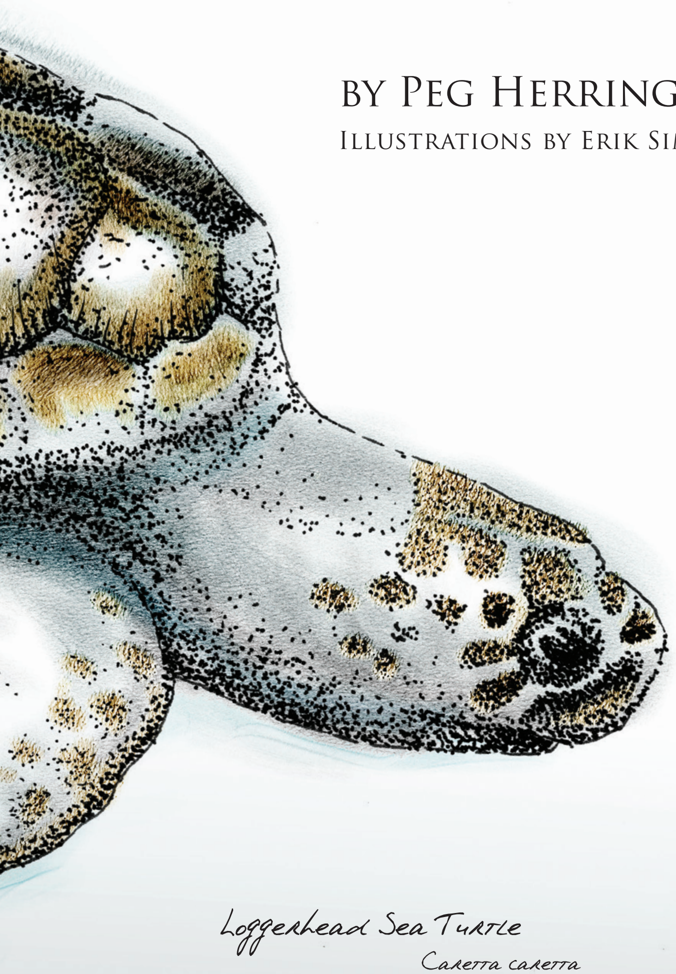
ILLUSTRATIONS BY ERIK SIMMONS

Sea turtles are some of the oldest, slowest growing creatures in the ocean; some species take up to 30 years to reach maturity. A researcher studying these ancient beasts might get the chance to observe just one generation. Selina Heppell, who has devoted much of her career to sea turtle conservation planning, doesn't want to wait that long.

Heppell is a marine ecologist at Oregon State University. She has worked with sharks, sea turtles, and West Coast rockfish, studying how populations of these long-lived species respond when conditions are disrupted in their deep ocean world. When such slow-growing creatures are harvested directly or accidentally killed in fishing operations, it can be hard for the population to recover. It is Heppell's job to figure out how many creatures need to be left alone—and where—in order for that population to survive.

"In the old days, these fish and turtles had refuges away from human impacts—isolated beaches, big ocean currents, the deep sea—where populations had a chance to replenish themselves," Heppell said. "Now, with modern technology, we can intensively harvest fish anywhere, anytime—far offshore, in deep submarine canyons, and continuously in any weather for months at a time." As refuges are lost, populations become more vulnerable and they lose their natural resilience.

But finding the right balance between adequate protection for sea life and sustainable fisheries for people is a tricky business. The ocean is vast and it's hard to count things that you can't actually see. Increasingly, Heppell is called on to navigate the murky waters of ocean management and policy, applying what she knows as a scientist to help craft recovery plans for endangered species such as sea turtles and overfished species such as the yelloweye rockfish.

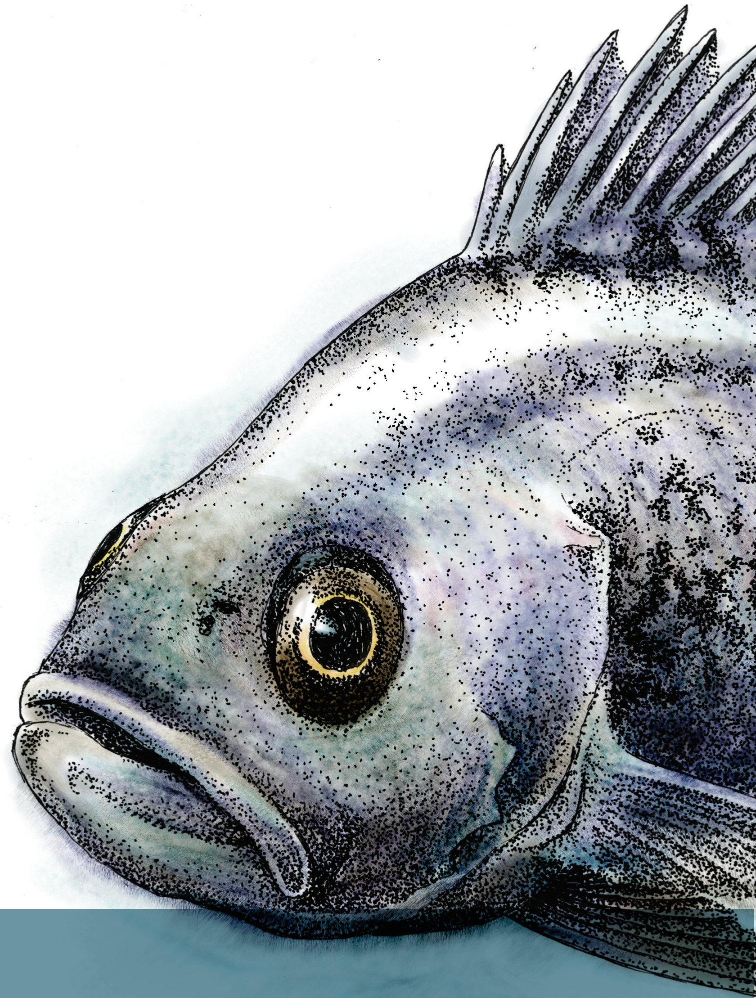


Loggerhead Sea Turtle

Caretta caretta

Heppell moves gracefully past old conflicts to help the fishing industry and conservation groups find common ground. As a result, she's been asked to advise the National Marine Fisheries Service and to serve on the Pacific Fisheries Management Council. Heppell connects the virtual world of mathematical models with the nuts-and-bolts management of harvest rates and conservation policies. She uses biological information about the animals she studies—their population size, distribution, behavior, habitat requirements—to simulate populations in "virtual space." Then she tests what might happen with various management strategies without putting at risk a population or an industry. "If the policy is too lax, we risk losing a population; if the policy is too conservative, we risk shutting down an industry unnecessarily. Testing models lets us get closer to the right measures to protect both the species and the industry."

As a panel member for a National Research Council review, Heppell recently evaluated data collection and modeling of sea turtle populations. At the time, she strongly recommended that government monitoring should shift from simply counting turtle nests on beaches to measuring survival and growth rates of turtles at sea. Such a shift of monitoring would have made it more possible to understand the effects of the BP oil spill on highly sensitive species, such as the Kemp's ridley sea turtle in the Gulf of Mexico.



Science need not be unfathomable. It requires explaining our assumptions and laying out the tools we use to reach our conclusions.

OSU marine ecologist Selina Heppell dives into marine policy with a group of teachers at OSU's Hatfield Marine Science Center in Newport. She unravels the complexity of conservation biology with tools as simple as M&Ms.
LYNN KETCHUM PHOTO.

"The Kemp's ridley has made a terrific comeback, thanks to intensive conservation efforts by Mexican and U.S. scientists, volunteers, conservation groups, and recovery support from the shrimping industry," Heppell said. "The oil spill has put their recovery in jeopardy; but we don't know how bad things really are. Our model simulations will be uncertain because we lack basic information about the turtles' life at sea."

In the highly charged world of fisheries management, Heppell insists on solid evidence to improve the mathematical models used to determine sustainable catch levels.

"Models can be dangerous tools," she said. "It's easy to pull the wool over someone's eyes with pages of complicated equations. Science need not be unfathomable. It requires explaining our assumptions and laying out the tools we use to reach our conclusions."

Heppell has been explaining the complexities of marine life and science since she was 12, when she began volunteering as a guide and interpreter at the Seattle Aquarium. She works hard to keep messages simple, but accurate. "People need to know about the seafood they eat, and how fishing can be modified to reduce negative impacts on the environment," she said. "I particularly love to talk to kids about the sea, and to combine math and biology. As a student, I loved science but

really didn't like math. Then I learned about models and their application to sea turtle conservation and I was hooked—math can help save endangered species. I try to convey that excitement to the undergraduate math-phobes that I teach now."

Science communication is central to the work of students in Heppell's lab, which she shares with her husband, Scott, a fisheries ecologist and physiologist who is also on the faculty of OSU's Department of Fisheries and Wildlife. Their students partner with people in the field, such as fishermen in Port Orford working with rockfish; Oregon coast communities working to develop marine reserves; and agency scientists working on grouper conservation in the Cayman Islands. In each case, they help build conservation plans based on rigorous science and evidence based methods.

Conservation biology is a relatively young science, and the Heppells are introducing these evidence-based methods to students around the world. In 2004, the Heppells started the International School of Conservation Biology in Croatia, an intensive short course that has engaged graduate students from 19 countries, primarily from eastern Europe where conservation biology is a new discipline and a new priority.

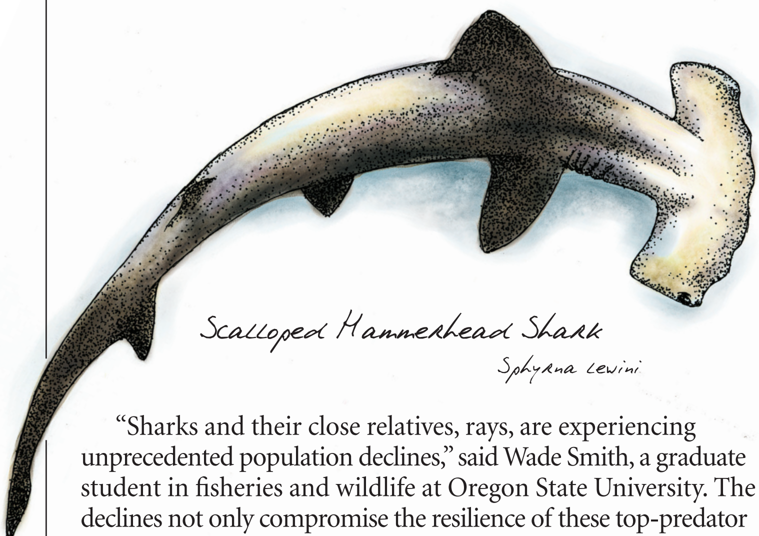
"If we scientists speak only among ourselves, we won't be effective," Heppell said. "We must work with fishermen, biologists, conservation groups, governments, and managers so that we understand the challenges that we each face and the populations we want to both protect and harvest. We all want long-term sustainability of ocean ecosystems. Combining good science with local knowledge is the key." OAP

The Chemical Signature *of* Sharks & Rays

By Peg Herring

With their toothy grins and killer reputation, sharks seize our imaginations. But there's more to their success than brute force. These predators hunt a wide variety of prey in a wide variety of habitats from tropical freshwater to the Arctic Ocean. Such species diversity has allowed sharks to dominate the seas for more than 400 million years, surviving upheavals of climate change and mass global extinctions. They grow slowly, mature late, and give birth to relatively few offspring. Until now, that was enough.

Sharks, like fishermen, hunt where the fish are. The intersection of sharks and fishermen has created both a growing international market for shark fins and a train wreck for sharks.



"Sharks and their close relatives, rays, are experiencing unprecedented population declines," said Wade Smith, a graduate student in fisheries and wildlife at Oregon State University. The declines not only compromise the resilience of these top-predator populations, they also tend to boost populations of some lower-level predators, creating changes in predator-prey relationships that ripple throughout the marine ecosystem. The declines are linked to overfishing and to accidental harvest when the target is some other fish.

Smith is exploring a method to track the movement of sharks and rays in order to identify critical times and places in their highly migratory life history. He's examining a variety of chemical markers deposited in cartilage that might record movement through the ocean like stamps on a passport.

"Chemical composition of vertebrae may serve as distinct tags that identify where individuals were born, where they traveled, and what environmental conditions they encountered along the way," Smith said. "Such information would help managers design more effective conservation plans for sharks and rays, including seasonal closures of migratory routes, gear restrictions in nursery areas, and critical areas for protection," he said.

Smith is the first to explore the effectiveness of tracking sharks and rays through chemical signatures in their vertebrae. He is working with OSU ecologists Selina Heppell and Jessica Miller and with collaborators in Mexico and Costa Rica.

To learn more, go to:
http://oregonstate.edu/heppell

CONNECTING

the genetics of salmon recovery

BY AIMEE LYN BROWN
PHOTOS BY JUSTIN BAILIE

Fifteen bodies slip through murky water. Over, under, around each other they move together like dancers, like trapeze artists. They spin, pause, loop.

Then, in one instant, it's *chaos.*

Water splashing, bodies collide as they slide from creek to walls; ethereal forms become solid, streaking back and forth across the cement bunker. A flex of muscle carries them

G THE DOTS:

upward to break the surface. Gravity shouts back and they crash down, torpedoing toward the shallow bottom. Their powerful movements boil the water, fill the air with raucous noise.

Waist-deep in the roiling water, a man in chest waders and a green rubber coat wields a net among the thrashing bodies. He muscles a slippery twenty-pounder onto a worktable. With an ordinary office single-hole punch, he quickly punctures out three dots of paper-thin tissue from the tail fin; with forceps, he plucks a few scales from the back. Quieting the movement for a moment, he calls up to a colleague standing above the tank: "Chinook, male, 93 centimeters."

The man standing above the tank snaps a picture of the fish; then the man in the green rubber coat slides the salmon gently into the creek next to the holding area. The big Chinook disappears upstream.

After recording data and registering samples, the two men repeat the process with the other 14 fish.

Wild coho tangle in the shallows of Big Creek near Astoria as they migrate upstream to spawn.

All of it—the splashing, the sampling, the setting free, the three dots—are part of ongoing research related to the long-term health of wild salmon populations in the Pacific Northwest. Call it the genetics of migration, or the genetics of recovery.

Currently, on the west coast of the United States, there are 28 distinct populations of Pacific salmon listed as either threatened or endangered under the Federal Endangered Species Act. Since listing began more than 20 years ago, and despite heroic efforts at recovery, none of these Pacific salmon populations have been removed from the list.

"We don't have a great measure of what the historic abundance of salmon was, but we know that it greatly exceeded today's returns," says Carl Schreck, a U.S. Geological Survey scientist with an appointment at Oregon State University. "In the case of salmon, we didn't even truly realize the fishery was sick until it was essentially dying."

Schreck is one of a generation of fisheries scientists whose careers have witnessed the decline of salmon in Oregon. He is joined by a legion of researchers studying salmon survival, including David Noakes, the director of the Oregon Hatchery Research Center. Here at this research center, the cement holding tank detours salmon on their migration up Fall Creek on the central Oregon coast.

With three dots of fin tissue and a few scale scrapings, Noakes and his colleague Joseph O'Neil, a biologist with Oregon Department of Fish and Wildlife, are collecting genetic samples from each fish. The samples function like a unique Social Security number, impossible to steal or duplicate, that can reveal the birthplace and some of the migration history of that fish.

Because of the way salmon move in the ocean, Oregon's commercial

In the case of salmon, we didn't even truly realize the fishery was sick until it was essentially dying.

At the end of its journey, the carcass of a spawned-out salmon resets the cycle for another generation.

fishermen often catch Chinook salmon reared in the rivers of California's Central Valley and the California and southern Oregon coasts. Once leaving their natal streams and entering the salt, these loose schools of fish move north along the coast of Oregon. These include migrating schools of threatened and endangered populations from the Sacramento and Klamath rivers.

For much of the 2010 salmon season, while fishing boomed off the north coast, commercial fishermen off Oregon's central coast were catching an average of three Chinook a day, earning captains about $225 per trip. Subtract deckhand wages, fuel costs, licenses, and boat maintenance, and $225 doesn't reach that far, says Jeff Feldner.

Feldner fished commercially out of Newport, Oregon for more than 30 years before joining OSU as the fleet manager for OSU's Project CROOS—Collaborative Research on Oregon Ocean Salmon. As an OSU Extension fisheries specialist, he spends more time on the phone than setting lines these days, but he's still a fishermen at heart, especially when he steps onboard his boat, the *Granville*. The dark wheelhouse is not much larger than a closet and piled with books, pictures, extension cords, coffee cups, and extra layers of waterproof clothes and gloves. Somehow the extra gear, the little bit of mess, makes it feel cozy, safe, like good things and great times have happened here. According to Feldner, they have.

"Commercial salmon fishing out of Newport is about the most fun I've ever had," Feldner says. "But in the 36 years since I started we've seen changes in the fishery and in management." Many of those changes are directly related to the decline and listing of those 28 populations of wild Pacific salmon under the Endangered Species Act. Increasingly, commercial salmon seasons have been shortened or closed to protect threatened runs.

Pacific salmon are born in the gravels of the region's rivers and streams. As adults they spend much of their lives in the open ocean, growing strong on the sea's plentiful food. They then return to their natal streams to spawn and die.

Big ocean-caught chinook salmon (above), king of the seafood market, record specifics of their life history in their DNA.

Jeff Feldner, relaxing in the wheelhouse of his fishing boat, reflects on 36 years of changes in the coastal salmon fishery.

This life cycle seems straightforward, but it is anything but simple. Depending on the species, the population, the individual, and the year, Pacific salmon may begin to migrate toward the ocean as soon as they leave the gravel, or they may wait a year or two before leaving their natal streams. Some linger for weeks in the estuary while others make a beeline for the strong offshore currents. Once in the ocean, some fish will remain for only one year, others may stay up to seven.

"There are shifts in ocean conditions, shifts in freshwater conditions, changes in predation and food sources," says Schreck. "One year smolts migrate early, the next year they go late. Even in the same year, some move at different times than others. There's nearly endless complexity to salmon life history."

Pacific salmon have managed to survive in large part because of this great diversity, says Schreck. Variability hedges the bets for survival when widespread changes occur in rivers, the ocean, or both. It can only be taken so far, though.

The National Oceanic and Atmospheric Administration Fisheries Service, in its 2010 Report to Congress, stated that "over the course of their life cycle, salmonids require suitable habitat in mainstem rivers, tributaries, coastal estuaries, wetlands, and the Pacific Ocean." Meeting these requirements is not always simple in today's world, says Pete Lawson, a salmon ecologist in NOAA's Northwest Fisheries Science Center. Some things can't be overcome through adaptation.

Fish are not superheroes, and it would be tough to say that there is anything in the genetic make-up of Pacific salmon that would help them to deal with the development of 200-foot-tall dams, the over-allocation of water for out-of-stream uses, overfishing, clearcuts, and the construction of superstores in wetlands.

"Salmon are incredibly tough," says Lawson. "But there are limits."

To better understand both limits and possibilities for recovery, managers needed new tools. For 40 years, scientists used coded-wire tags placed in the snouts of some hatchery-reared salmon to track the movement of fish in the ocean. When the fish were caught, these tags worked like tiny ID bracelets, providing rudimentary information about the origin of the hatchery fish.

"The information from the tags was useful but incomplete," says Gil Sylvia, the superintendent of OSU's Coastal Oregon Marine Experiment Station. "We needed the ability to discriminate salmon stocks in real time on the open ocean to avoid weak stocks and target healthy stocks."

Hatfield Marine Science Center became an epicenter for a project to meet this need, says Sylvia. A collaborative team of scientists from academia and federal and state agencies joined with local commercial fishermen to begin identifying Pacific salmon by their genetic make-up.

Remember the hole-punch. Remember the three dots and the scale samples.

The researchers who formed Project CROOS asked fishermen to collect small samples of fin and scale from the fish they caught in the ocean, and to send these samples back to Hatfield. There, researchers dissolved the samples in a sea of chemicals, extracted DNA, and identified genetic markers. Comparing these markers to a library of other genetic markers, researchers could pinpoint specific runs of fish. The magic of all this is that it worked, and it worked fast.

"When the scientists at Hatfield first asked us to take part, we voluntarily collected about 200 samples from fish caught in the open ocean," says Feldner. "A week later, we knew where 190 of the fish had come from—the specific rivers where they were reared."

Of the 200 fish the fishermen sampled, only two carried coded-wire tags from hatcheries. It would have taken months for the information from those tags to be available to managers. The potential benefit of the new science was a revelation.

"Coded-wire tags were used only on hatchery fish so very little was known about wild fish," says Michael Banks, the director of OSU's Cooperative Institute for Marine Resource Studies. "Genetic sampling told us not just where one fish had come from, it told us who all these fish were and it did it in nearly real time. It was the beginning of uncovering the genes that trigger different life histories and different migrations in the ocean."

That was five years ago. Since then, Project CROOS has steadily refined its approach using genetic information to reduce the unintended catch of weak

Wild salmon face obstacles throughout their lives. Researchers hope that understanding genetic diversity in salmon will help wild populations survive.

salmon stocks, avoid the long-term and widespread closures of salmon fisheries, and possibly help to ensure the survival of Pacific salmon populations.

"Pacific salmon are thought to have discreet migratory paths in the ocean," says Banks. "If we can understand the genetics that guide these migrations, we can direct fishermen to healthy runs and avoid those that are in trouble."

In studying the genetics of migration, Banks and his colleagues have created genetic IDs of 7,448 individual fish. They've tracked adults back to their natal streams and determined not only the species and population, but also the time the fish migrated into the ocean and where they traveled once there. Those three little dots collected at the Oregon Hatchery Research Center are part of the genetic library used to help identify fish sampled in the open ocean.

"Populations of fish that breed separately will become different," says Banks. "These differences make it possible for us to identify families of fish and to know where they came from."

Salmon are waylaid at the Oregon Hatchery Research Center, where researchers collect tiny samples of tissue before sending the fish on their way upstream.

In the future, this knowledge might help managers protect specific fish populations in specific times and places. "For two seasons, the Pacific salmon fishery was closed off the coast of California and Oregon in order to protect one weak stock," says Kathleen O'Malley, part of OSU's Coastal Oregon Marine Experiment Station. "A primary goal is to use what we're learning about genetics to help reestablish weak stocks while continuing to provide a fishery for commercial fishermen."

O'Malley is exploring the genetics of migration timing. She's asking not only which fish are which, but also where are these fish and when. By identifying the genes that influence when adult salmon return to spawn and when juveniles migrate to the ocean, she hopes to better understand how salmon populations adapt to their local environments.

We're learning about genetics to help threatened stocks while continuing to provide a fishery for

Current thinking is that adults spawn at the time of year that most benefits the growth and survival of offspring as they emerge from the gravel. But O'Malley points out that another crucial component is the seasonal timing of juveniles entering the ocean. During the first few months of marine residence, juvenile salmon typically experience mortality rates greater than 90 percent, she says. Therefore, selection should favor timing of out-migration with optimal ocean conditions, such as suitable temperature regimes, vertical mixing, prey availability, and low numbers of competitors and predators.

This new focus on genetics is helping researchers better understand how Pacific salmon in the region live, move, and die. Just like the fish, the science isn't simple. It's not neat, and sometimes it's not pretty.

It is hopeful, though, says Gil Sylvia from his office at Hatfield where he's buried under paperwork requests and grant proposals seeking funding to keep Project CROOS running for another year. Those three dots—they are working. OAP

Wet Pet Vet

OSU's Tim Miller-Morgan helps patients that look green around the gills.

by Tiffany Woods

OSU Extension aquatic veterinarian Dr. Tim Miller-Morgan examines patients during his rounds at the Oregon Coast Aquarium in Newport. It's his job to keep things going swimmingly.

LYNN KETCHUM PHOTO

Dr. Tim Miller-Morgan wiggles his fingers into surgical gloves. They snap against his wrists like rubber bands. On the operating table in front of him, a sedated patient lies on her back. She was diagnosed with a parasitic infection a week ago, so she has been undergoing treatments. Today, she's in for a checkup.

Her name is Pebbles, and she's a 3-foot-long, pointy-nosed wolf eel with a ribbon-like tail that ripples like a flag in the wind. She lives at Oregon State University's Hatfield Marine Science Center in Newport.

Miller-Morgan gently probes her beet-red gills where microscopic flukes had previously hindered her breathing. He snips off a speck-sized piece of tissue that he will later examine under a microscope to see if any flukes remain.

Suddenly Pebbles stops breathing. Worried, Miller-Morgan quickly lifts her out of the sedative-laced bath and puts her into water without the tranquilizing drug. Time seems to stand still as Miller-Morgan gently holds her head. "She's slowed down more than I like," he says. Then ever so slightly her mouth opens and closes. Everyone relaxes. Pebbles will be fine. And the flukes, it will turn out, are gone.

They look at koi as living art, as if they're purchasing a living Picasso.

Welcome to the watery world of Miller-Morgan, the aquatic veterinarian with Oregon Sea Grant Extension at OSU. He's a busy guy. As the head of OSU's Ornamental Fish Health Program, he teaches importers, retailers, hobbyists, college students, and veterinarians how to care for underwater pets. He has no shortage of people to educate. In the United States alone, 14 million households own 183 million fish, according to a recent survey by the American Pet Products Association.

One of the best ways to see his impact is to visit the annual Northwest Koi and Goldfish Show in Portland. Koi shows are like dog shows, except the fish don't look like their owners. A couple of years ago, Miller-Morgan and his assistant, Dennis Glaze, were asked to inspect the hygiene and handling practices at the show to prevent the spread of disease. Hygiene is important at shows because koi are big business. Miller-Morgan once performed abdominal surgery on one valued at about $5,000; and he recalls one person paying $70,000 for a single koi.

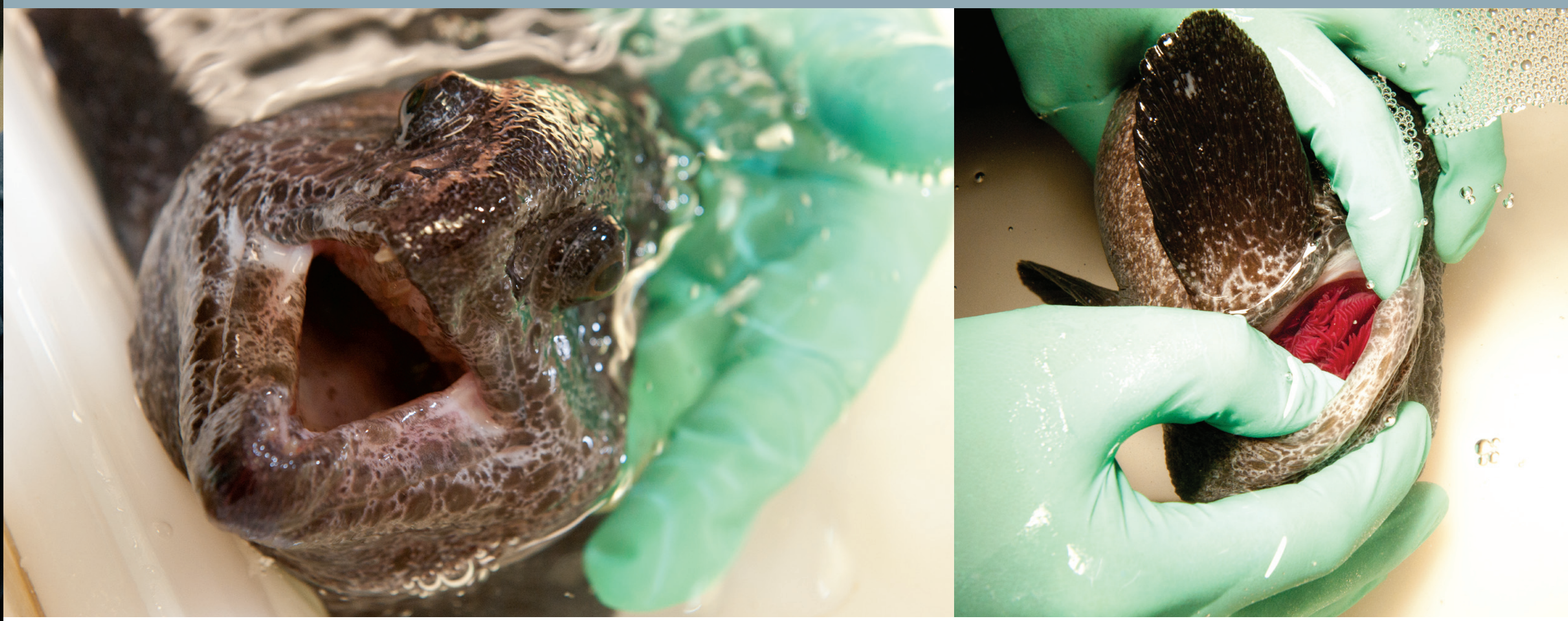
LYNN KETCHUM

"You're kidding!" A visitor reacts as Tim Miller-Morgan introduces her to friendly koi at the Hatfield Marine Science Center Teaching Lab in Newport. Koi *are* friendly and can be taught to eat out of your hand. "Koi like to interact with people," Miller-Morgan says. "You do get pretty attached to them."

"They look at it as living art, as if they're purchasing a living Picasso," he says, explaining why someone would fork over a down payment on a house to buy a fish.

Of particular concern to koi owners is the contagious and deadly koi herpes virus, which inhibits breathing and can wipe out entire ponds. "It's nasty. If it gets into your pond, any surviving fish

One man lost his entire koi collection, worth $250,000, when he added a single fish that had not been screened for the virus.



Pebbles the wolf eel undergoes a thorough exam to remove flukes from her gills. The good, the bad, and the ugly receive equal care in OSU's Aquatic Health and Husbandry Teaching Lab.
LYNN KETCHUM PHOTO

are infected for life," Miller-Morgan says. Because koi can have the virus but not show symptoms, he and several OSU colleagues are trying to indentify tissue in which the koi herpes virus hides, the genes expressed during latency, and factors (perhaps temperature) that activate the virus. They aim to develop a test that would indentify carriers by looking for the DNA of the virus.

"The OSU team is doing some of the best koi herpes virus research in the country," says koi judge Grant Patton, of South Carolina, who sits on an Associated Koi Clubs of America committee that awarded OSU the funding for the research. If successful, their work would make koi buying less risky. Miller-Morgan recalled how one man lost his entire koi collection, worth $250,000, when he added a single fish that had not been screened for the virus. It was Miller-Morgan's colleagues at OSU's veterinary diagnostic laboratory who made the difficult diagnosis.

Miller-Morgan's expertise is recognized throughout the country and abroad. He has taught seminars in about 25 states as well as in Australia, India, Indonesia, and Israel. He helped write the curriculum for a yearlong online course called the Koi Health Advisor program, which trains volunteers across the nation to care for koi and teach hobbyists how to properly care for their own fish. He's traveled around the country to teach the hands-on part of the course. Along those lines, he also helped develop the aquarium science program at Oregon Coast Community College, where he also teaches.

Many of the most popular ornamental fish species are collected in tropical waters far from U.S. shores. How those fish are handled during their transport from reef to aquarium greatly affects their health and survival. Miller-Morgan has seen reef fish in Indonesia sit on a boat in plastic bags of water for up to three weeks before they're sent to an export facility. That's useful reconnaissance for U.S. buyers so they don't shell out money for stressed-out, malnourished fish that die shortly after touching down on American soil.

Miller-Morgan collaborated with Sea Dwelling Creatures, an ornamental fish wholesaler in Los Angeles, to develop methods for safely transporting healthy marine ornamental fish. He helped them take blood samples, track water quality, and study how shipping impacted the fish. Working with the in-house veterinarian, he developed handling procedures that give the fish more time to acclimate to the water in their new tanks and eliminate unnecessary use of certain chemicals. He also accompanied staff members to Indonesia to work with suppliers there to improve the health of the animals. "Dr. Tim is awesome," says co-owner Eric Cohen.

As any good doctor, Miller-Morgan can be found making weekly rounds of his patients, in his case at the Hatfield Marine Science Center and the nearby Oregon Coast Aquarium. With clipboard and flashlight in hand, he checks the vital signs of snooks, wrasses, red drums, anemones, hairy hermit crabs, jellyfish, and the rest.

It's hard to miss him. Silhouetted against the floor-to-ceiling tanks, his 6-foot-5-inch frame towers over most visitors in the dark exhibit rooms. He's a relaxed man with a gentle touch that can put sharks in a sleep-like trance. Maybe it's all the years watching fish peacefully float by in aquariums that have given him such a calm demeanor. Yes, aquariums are good stress-relievers, he says, as long as you're not the one maintaining them. Although he doesn't own any fish, he does have a favorite: the spiny lumpsucker, an inflatable, golf ball-sized cutie with fins that stick like Post-It notes. And his favorite fish to eat is tuna. Just don't tell his patients.

One Tuesday morning finds him at the Oregon Coast Aquarium checking out a tank of tetras. Earlier, some

LYNN KETCHUM

LYNN KETCHUM

The doctor is always in, whether it's to care for a $3,000 koi or a $3/lb rockfish. "When we bring them into captivity, we have an obligation to take care of them," Miller-Morgan said.

tetras had died in this tank; he's trying to nail down the cause. He's looking for physical and behavioral abnormalities: ulcers, tattered fins, changes in color. A fish that's swimming with its mouth open could mean gill problems, or one that rubs its belly along the tank bottom could have skin parasites.

Detective work is part of his job. Earlier this year, Miller-Morgan and an aquarist noticed that Deriq, a 40-pound octopus at the Hatfield center, was barely breathing or moving. They took him to the hospital ward where he soon died. Deriq the octopus was *the* star attraction at the center and had developed a fan club thanks to a webcam in his tank that streamed live video of him onto the Internet. He even had his own Facebook page, which listed his interests as swimming, changing color, eating, playing with toys, and taking things apart. The day after his death, his Facebook page was filled with condolences.

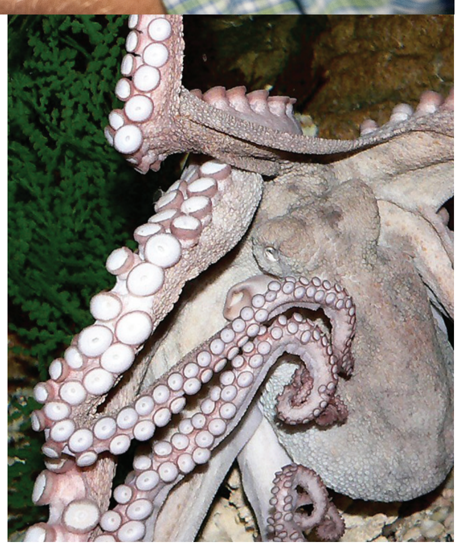
Did metals leach from the camera in the tank? Was it something in the water? Miller-Morgan autopsied Deriq and lab work revealed that a parasite had infected his liver, intestines, and heart. Working with colleagues at the OSU

Aquariums are good stress-relievers as long as you're not the one maintaining them.

School of Veterinary Medicine, Miller-Morgan suspects that the parasite came in on crabs that Deriq ate.

Finished with the tetras, Miller-Morgan moves on to a tank where a dozen sea pens *should* be displaying their orange plumes like peacocks. Instead, "they have an unhappy, 'I'm itchy' look," he says. Earlier, flea-like amphipods had been chewing on the sea pens, and now protozoans are pestering them. Irritated, the sea pens have retreated into the sand. Miller-Morgan recommends to the aquarist that he put them in a different tank where they can be washed in a mild formaldehyde mixture and then run fresh water through their display tank.

Next, he walks to the aquarium's warehouse-like hospital ward. A few years ago, an Animal Planet television crew filmed him there, gluing a contact lens onto the ulcerated eye of a rockfish, inserting a feeding tube into a sea dragon, and tending to a skate with a sore on its back. This time his patient is a rockfish with a half-inch-deep gouge on its snout. Miller-Morgan had treated the wound earlier and now, strapping on a headlamp, he checks his patient's progress. The sedated fish looks at him,



STOCK.XCHNG

Miller-Morgan's international work has resulted in improved practices for the multimillion-dollar ornamental fish industry and increased health of ornamental fish.

LYNN KETCHUM

helpless. But Miller-Morgan knows to be careful: the spiny dorsal fin is a weapon. Yes, his job is not without risks. He was once bitten by a skate. "I was demonstrating how jaw movement returns before respiration—and it did," he says.

He runs his hands down the side of the fish to check its muscle mass. The thrashing animal splashes water on his shirt. It's losing equilibrium, the doctor explains. Fish in this phase can jump out of their containers. He jokes that the probability of a fish jumping out of its tank is directly proportional to the value of the fish, which means this one is very likely to stay put. He dabs at the wound with a piece of white gauze. "We're seeing some good healing but you're looking

From tetras to wolf eels to sharks, all his patients get equal treatment.

at a year to a year and a half," he says. "It could be six months before this fish is back on display."

STOCK.XCHNG

Rockfish can be easily caught off the coast and purchased at the grocery store, but Miller-Morgan treats this one with the same tender care as he does with more expensive or exotic species. From tiny tetras to snake-like wolf eels to human-size sharks, all of his patients get equal treatment.

"They're animals, and when we bring them into captivity we have an obligation to take care of them no matter what they are," says Miller-Morgan, who has a framed copy of the veterinarian's version of the Hippocratic oath on his office wall. He tucks his headlamp into his paramedics bag. He's headed back to the Hatfield center to brief a room of concerned volunteers on the death of Deriq the octopus. It's just another day at the office for the OSU fish doctor. OAP

For more information, see:
http://hmsc.oregonstate.edu/visitor/ornamental-fish-health

Invading species

lurk in eastern Oregon waterways

BY RACHEL BECK

It's not just coastal areas where aquatic invasive species wreak havoc. Waterways in southern and eastern Oregon also have to deal with aquatic critters that have made themselves at home—invited or not. Sam Chan, an OSU Extension educator and chair of the Oregon Invasive Species Council, works to understand and combat these invaders. Below are some of the species threatening eastern Oregon on Chan's radar.

Rusty crayfish *(Orconectes rusticus)*

This creature has made its way to lakes and streams far beyond its native Ohio River basin. Recently, it was found in the John Day River. How did it get all that way? Anglers using crayfish for bait may have introduced the species. Ironically, it's also possible that students and their teachers, who buy the crayfish in popular science education kits, have released the animals at the end of the lesson.

Rusty crayfish are extremely disruptive. They chase native crayfish out of their burrows, making them more susceptible to predators. They voraciously eat aquatic plants, fish eggs, and invertebrates, damaging habitats and food sources for other fish. Humans aren't immune to their rough-housing: rusty crayfish have long, strong claws that can injure bare toes.

Tui chub *(Gila bicolor)*

Tui chub were introduced to eastern Oregon waterways as live bait. They feed on the zooplankton that keep blue-green algae in check. Over time, the tui chub in Diamond Lake diminished the zooplankton enough so that blue-green algae proliferated in massive toxic blooms. In 2006, the problem was so bad that officials drained most of the lake and poisoned the remaining water to get rid of the chub. So far, tui chub haven't returned to Diamond Lake, but they have been found in nearby connecting waterways.

Brown trout *(Salmo trutta)*

Brown trout were brought to the U.S. from Europe more than 100 years ago for recreational fishing, according to Jason Dunham, an aquatic ecologist for the U.S. Geological Survey in Corvallis. Since then, the species has flourished in the Pacific Northwest. Anglers are big fans of the fish, which are stocked in many lakes and streams. The trout can grow to more than 20 pounds in eastern Oregon lakes and reservoirs.

But while brown trout thrive in Oregon waterways, they do so at the expense of native species. Brown trout eat native fish, including threatened bull trout, and compete with them for food and space. It appears they may also be healthy carriers of disease that can spread to native fish species. Ironically, brown trout are listed as "threatened" in their native Europe.

American shad *(Alosa sapidissima)*

Like brown trout, American shad didn't get here by accident. When people from the East Coast began migrating west in the 1800s, Chan says, they found abundant salmon runs to provide them with food. However, many newcomers preferred the taste of a fish native to their eastern birthplaces: American shad. There was so much demand for shad, the government imported the fish and stocked the Columbia and Willamette rivers with shad in the late 1880s. Now, runs of American shad on the Columbia River are higher than those of native salmon species. They have become carriers of seal worms, a parasite that infects fish and can be passed to humans, and they compete with native species for food and habitat.

Think you've spotted an invasive species? Visit oregoninvasiveshotline.org to identify and report invasives.

MAIL TRIBUNE PHOTO

Tui chub had so devastated the native food web in Diamond Lake that managers turned to rotenone to kill the invasive fish. So far, the chub have not returned to Diamond Lake.

NIGHT AT THE MUSEUM

BY AIMEE LYN BROWN

Half a million eyes peer out from behind thick glass jars. They seem to follow me as I move down rows of metal shelves, stacked floor to ceiling with specimens.

On one corner, right at chin height, a lungfish sits. Pickled in alcohol, it resembles a human organ, and I think of the actor Steve Martin in the movie, "The Man with Two Brains." I pick up the jar. The lungfish bobs up and down as I turn the container to get a better look. It has small pectoral fins and gill covers that look like wrinkles. It peers back at me with glassy dime-sized eyes. The fluorescent lights flicker and my imagination runs. I hope that the power stays on.


LYNN KETCHUM

A quarter million specimens housed in OSU's preeminent Ichthyology Collection will soon have a new home in Nash Hall, safe from fire and seismic disturbances. Updating and adding to the collection is the job of curator and fish explorer Brian Sidlauskas.

There are more that 250,000 specimens in Oregon State University's Ichthyology Collection, representing 2,500 different species of fish, one of the world's premier collections of freshwater fish local to the Pacific Northwest. It's also a little creepy. The collection is being updated by its most recent curator, Brian , an assistant professor in the College of Agricultural Sciences.

"These specimens, and the additional genetic material stored in freezers here, are part of a global library of biodiversity continually updated by scientists and researchers in institutions around the world," says Sidlauskas as he hands me a pint-sized jar holding a Chinook salmon smolt. Special enzymes have been added to the alcohol solution, and instead of seeing the fish as a solid pickled creature, I see the cartilage that would have matured into bone to form a skeleton. It's like looking at a 3-D X-ray.

"Trained researchers can use the collection to understand the evolution and morphology of a specific fish from a specific location," says Sidlauskas. "These tools help us better understand life history and development, population shifts, and changes that may have affected habitat and food availability. We can learn about the fish, and also about the ecosystem in which the fish lived."

Much like how an inter-library loan program functions, researchers at OSU and other institutions can check out samples from the collection for their own work and purposes. In addition to the fish collection, OSU also has extensive collections of plants, seeds, reptiles, and insects. "We are the biodiversity library for the region," says Sidlauskas.

The OSU fish collection was started in the late 1930s and has had only two other curators since then. In addition to its extensive samples of regional fish, it holds material from around the globe, and continually adds new specimens. Sidlauskas recently returned from collecting trips in South America where he discovered, and brought back to OSU, two previously unidentified species of the fish genus Leporinus.

"There are currently about 31,000 species of fish known in the world, and their number continues to grow," says Sidlauskas, who will travel this winter to Guyana with funding from the Smithsonian to collect fish in a river system that has never before been sampled. "There is roughly one new species of freshwater fish being discovered each day, most of them in the tropics. In terms of biodiversity, freshwater fish comprise about one quarter of all known vertebrates."

The College of Agricultural Sciences is funding a complete-makeover of the Ichthyology Collection. Records are being digitized into a searchable database, and the largest specimens are being transferred into archival-quality stainless steel tanks. The tanks will ensure the collection of salmon, sturgeons, suckers, and others will be preserved in perpetuity, says Sidlauskas.

The tanks will also shutter the fish from view, closing the lids of unseeing eyes. I walk one more time down the rows of glass jars, not sure how I feel about that. As long as the lights stay on, creepy is good for the imagination. OAP

Zebrafish:
a living window

by Aimee Lyn Brown

There's a fish out there that might hold the secret to why some people get cancer and why some don't. A fish that is mostly transparent for the first ten days of its life, allowing researchers to watch as its organs form and its body develops. As a window into human health, scientists credit *Danio rerio* - zebrafish.

In a Petri dish the size of a saucer, 20 fertilized fish eggs rest in cool fresh water. They are round bubbles, milky looking but see-through. A female zebrafish, about the size of a standard office paperclip, laid the eggs this morning; a male zebrafish fertilized them seconds later.

Before the parents can eat the eggs, which are incredibly high in protein, researchers collect them from their specially made tanks at Oregon State University's Sinnhuber Aquatic Research Laboratory. Researchers then count the eggs and parcel them out to different studies that range from uncovering causes of childhood disease to the impact of common chemicals on muscle and nervous system development in human children.

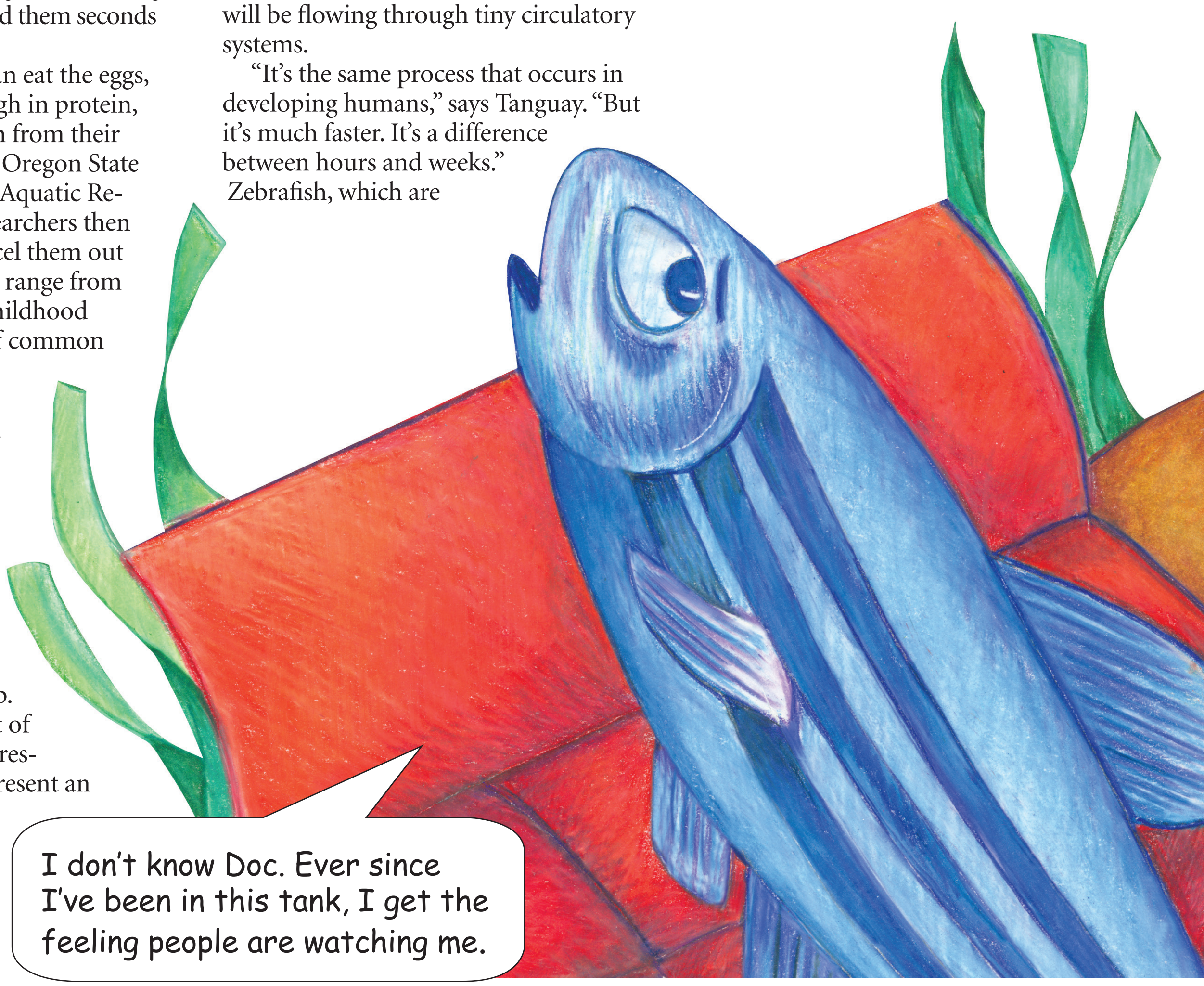
"Many human diseases can be modeled in zebrafish," says Robert Tanguay, an OSU College of Agricultural Sciences professor and director of the Sinnhuber lab. "With about 80 percent of genes in humans also present in these fish, they present an opportunity to better understand risks that chemicals pose to human health."

By this afternoon, the developing eggs will have taken on a slightly different shape. Their eyes will begin to take form. By lunchtime tomorrow, they will have beating hearts. Another 24 hours and the fish will be swimming. Blood will be flowing through tiny circulatory systems.

"It's the same process that occurs in developing humans," says Tanguay. "But it's much faster. It's a difference between hours and weeks."

Zebrafish, which are commonly sold in pet stores for home freshwater aquariums, have been used for research at OSU since the mid 1990s, and used worldwide in medical research programs for more than 30 years.

At the Sinnhuber lab, researchers capture about 25,000 eggs each day for studies related to human health. These studies explore questions like, "What are the implications of pesticide exposure on developing organisms, including human embryos?" or, "Is the mental disease



schizophrenia caused by environmental exposure to chemicals during development?" The rapid developmental rate of the eggs means that researchers can run many tests in a short time on a huge number of subjects. And that means that answers can be found, not over the course of decades, but in months and weeks. As a result, scientists from around the world use zebrafish to study genetics, human health, and the development of vertebrates.

Back in the lab, Britton Goodale, an OSU graduate student, is studying how poly aromatic hydrocarbons (PAHs) interact with, and possibly disrupt, normal vertebrate development. In some cases, PAHs are a significant toxicological health concern. They can be produced in the environment by both human and natural events. Sources of PAHs can include vegetation; geological processes including seeps, coal outcrops, crude oil spills and the release of fossil fuels; and the high temperature combustion of organic materials, as in the case of forest fires, car exhaust and the burning of wood stoves.

Goodale uses a long, very slender, very delicate needle to inject small amounts of PAHs into the zebrafish eggs. She will observe the eggs over the next few days as they develop into larvae. During this stage, the larvae do not yet need to eat and the researchers have ultimate control over their developmental conditions. Goodale will watch for early developmental markers that signal PAH exposure. PAHs have the capacity to cross the placenta during early vertebrate development, but it is not yet known how, and at what level, they affect embryo development. This work may help to close that gap in knowledge, says Tanguay.

Much of the work done with zebrafish is transferable to humans. From offering clues to human deafness, to helping determine how a heart might heal itself after cardiac arrest, the tiny fish are helping to enhance medical knowledge that benefits human health and wellbeing. Jill Franzosa, a PhD candidate in the lab, is using zebrafish in early developmental stages to study the impact of aging on tissue regeneration. Her work could improve therapies for the restoration of individual cell types and tissues in humans.

"Many human diseases can be modeled in zebrafish."

The National Institutes of Health and the National Institutes of Environmental and Health Sciences have granted the Tanguay group over $1 million in funding this year alone to train new researchers in the use of aquatic models, like zebrafish, and to use them to develop new studies related to the effects of environmental exposure to chemicals, nanomaterials, and pharmaceuticals on human health. Tanguay is also working to understand how to translate results from zebrafish to humans to help promote tissue replacement following disease or injury.

"We have a defined goal: to understand the ways in which a specific chemical or substance causes harmful effects to living things, and then to use that information to protect humans and the environment," says Tanguay. "Our ability to learn from the studies conducted in the lab relates directly to our goal to prevent diseases and illnesses that plague our families and communities."

A tiny fish egg sits under a microscope. As a researcher watches, organs develop, a heart begins to pump. A tiny syringe carrying a chemical common in the human environment pierces the embryo. A shift occurs. A discovery is made. A life is changed. OAP

For more information, see:
http://ehsc.oregonstate.edu/aquatic

ILLUSTRATION: TOM WEEKS

LYNN KETCHUM

FISH FOR SUPPER

BY PEG HERRING

Oregon has the world's finest seafood. And Oregon State University has state-of-the-science research that helps keep seafood fresh, safe, and abundant.

Take oysters, for example. For many people, slurping down a raw oyster straight from the shell is a gastronomic delight. For a few people, that delight can be followed by a belly punch. There's a nasty group of organisms called *Vibrio* that lurks in raw shellfish and can cause gastroenteritis. Researchers at OSU have found ways to kill *Vibrio* by subjecting oysters in the shell to very high pressure for about two minutes. The result is safe-to-eat, easy-to-shuck raw oysters.

Seafood has a notoriously short shelf life. Fish, like visitors, stink after three days. OSU food technologists have developed a thin protective film that can be used to coat fish fillets to keep them fresh much longer. Yanyun Zhao and research associate Jingyun Duan developed the edible coating from a mixture of fish oil and chitosan made from crustacean shells. The coating not only increases the shelf life of fresh fillets, it also adds nutritious omega-3 fatty acids to less oily fish.

Some seafood gets a bad rap for containing mercury. Because fish absorb mercury from their environment, fish that live in contaminated water or those that are older, larger, and higher on the food chain tend to accumulate more methylmercury in their tissues. Locally caught Oregon salmon, shrimp, flounder, and oysters are very low in mercury. But until recently, mercury content in tuna was averaged for all species, with no distinction made between small, young Oregon albacore and much larger, older tuna from the south Pacific.

OSU researchers compared mercury levels of commercial species of tuna and found that albacore caught off the Pacific Northwest coast have substantially lower mercury levels than the rest, well below FDA limits. And these small, cold-water-loving tuna are notably higher in omega-3 fatty acids.

What about sustainability? Recent reports of declining ocean stocks and closures of salmon fishing seasons remind us that seafood is not limitless. Fisheries managers try to encourage use of abundant fish populations and reduce harvest of weak stocks. But a strange new fish on the market might not be immediately embraced by consumers.

Jae Park has helped pioneer ways to process low-value fish into surimi, a seafood product that can be made to imitate popular seafood like crab and scallops. His research turned fish that nobody wanted into a high-value product that revitalized fisheries in Oregon and beyond. Since 1993, Park and colleagues have hosted the Surimi School at the OSU Seafood Lab in Astoria and in locations around the world to demonstrate new surimi processing techniques to food scientists and manufacturers. Since then, surimi has become a major international commodity with an annual value of $2.2 billion.

Okay, so Oregon seafood is safe and sustainable. But what if it glows in the dark? As weird as it seems, glowing seafood does not present a food safety problem, nor does it reflect mishandling during processing, according to Kaety Hildenbrand, an OSU Sea Grant Extension specialist. "It's caused by a harmless marine bacteria and it's surprisingly common," she says, especially in seafoods that have been processed with added salt.

Something to look forward to at your next candlelight dinner. OAP

Seeing the river for the **fish** by Megan McKenzie

Walking by the riverside, Jerri Bartholomew passes hovering stoneflies and stalking herons, keeping her eyes on the water. Bartholomew is a research scientist—studying salmon and the parasites that infect them. She's also an artist—casting glass into forms inspired by her river work.

Bartholomew came to Oregon State University after completing an undergraduate degree in biology at Penn State. She thought that Corvallis was a good place to be, but it was a fish disease class taught by distinguished professor John L. Fryer that reeled her in. Soon she embarked on a Ph.D., under Fryer's direction.

"Oregon is a long way from Pennsylvania," said Bartholomew, but "here is where I could do the research I wanted to do, and this place became home."

Thirty years later, the watery world of salmon continues to suffuse her work, her art, and her awareness. Bartholomew is now the director of OSU's John L. Fryer Salmon Disease Laboratory.

The fish lab, unassuming yet innovative, is one of the preeminent facilities in the world to study fish pathogens, and it is here that Bartholomew seeks clues to why salmon populations get sick and how she might help bring them back to health.

Salmonids (salmon and trout) have had a difficult run of it here in the Pacific Northwest. In the Klamath River Basin system, weak salmon returns coincide with severe parasite infections. Most of Bartholomew's current work focuses on the microscopic parasite *Ceratomyxa shasta*, which infects salmonids from northern California to Alaska.

These parasites have a complex life cycle involving two hosts that never actually come in contact with one another: tiny segmented worms that live at the bottom of rivers, and the fish swimming above. The worms, quietly waving among dark, slippery rocks, release puffs of spores into the river. These tiny spores drift in dilute clouds, infecting salmon on contact. When the sick fish die, billows of an altogether different form of spore emanate from their bloated bellies, settling down onto uninfected worms and reinitiating the cycle.

To get a clearer idea about the dynamics of this interaction, Bartholomew and her team visit sites in the Klamath, taking water, fish, and worm samples. It's clear from the data they've collected so far that when water temperatures are high, water flow is low, or parasite spore levels are high, salmon have a harder time resisting infection. Also, some fish stocks are more resistant to the parasite than others, and some strains of the parasite are more virulent.

"It's exciting to look at the molecular basis of immune function and parasite evolution," said Bartholomew, "but I don't want to spend all my time studying the infection; I want to *do* something about it."

The fish are ever more susceptible to infection due to rising water temperatures and changes in

LYNN KETCHUM

seasonal flows. Bartholomew is looking for ways to reign in parasite dispersion and foster salmon survival. She works closely with biologists from the Oregon Department of Fish and Wildlife (who assist with studies on Oregon's Klamath River tributaries), the U.S. Fish and Wildlife Service (who track infection rates in wild salmonid populations), and the Yurok and Karuk tribes (who collect Klamath water and worm samples), pulling together their data sets and her own.

The results will be part of an environmental review by the U.S. Department of the Interior and for Congressional consideration to remove four dams and begin large-scale restoration of the Klamath River. "We are being asked what might make a difference for the fish," said Bartholomew. She's watching the water to learn the answer. OAP

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