Flows, Fertilizer and Food: Investigations into Delta Smelt Habitat Decline

How did the tiny (5-7 cm) delta smelt end up before the US Supreme Court at the center of a fight over California water rights? Once an abundant fish in the upper San Francisco Estuary and the California Delta, delta smelt (*Hypomesus transpacificus*) has undergone such a substantial decline since the early 1980s, that it is now classified as threatened by the federal government and endangered by the state of California. Delta smelt is considered an indicator species, the quintessential “canary in the coal mine,” and this decline indicates trouble in the Delta’s ecosystem. Responding to a sharp decline in abundance of delta smelt and three other fish species around 2002, scientists from state and federal agencies partnering with academic scientists from the Romberg Tiburon Center (RTC) and other institutions have been working to understand how the ecosystem is changing.

Delta smelt spend most of their one-year life span in the low-salinity zone, where freshwater from the Sacramento and San Joaquin rivers mixes with ocean waters coming into San Francisco Bay. This zone is usually located in the western Delta and eastern Suisun Bay, but it migrates seaward during times of high freshwater inflow, and eastward during periods of low freshwater input. In early winter the fish migrate upstream to spawn in freshwater. Eggs, attached to the bottom, hatch from March to May, and the larvae spend a month or two in freshwater before migrating to the low-salinity zone.

Although delta smelt are small, weak swimmers and have very specific habitat requirements, the San Francisco Estuary once provided suitable habitat in abundance, and these fish thrived. Many of the changes made to the estuary could be contributing to the decline. They include altered seasonal patterns of freshwater flow due to upstream damming, diversion of freshwater from the Delta for irrigation and drinking water, a large influx of nutrients from agricultural

continued on page 4
Perched on the shore of San Francisco Bay, the constant ebb and flow of the tide brings something new to the Center every day. This predictable pace is punctuated by major perturbations as exemplified by the Japan tsunami. The range of science at RTC is sufficiently broad such that both the regular fluctuations and the irregular but significant disruptions fall under the scope of our research.

This issue of the *bayside* focuses on the major field program examining the ecology of the Bay/Delta region and especially the delta smelt, with the ultimate goal of determining why there is such reduced productivity in SF Bay, the largest west coast estuary, when compared to other estuaries. There are many factors contributing to the present stressed condition; three RTC labs are collaborating on this new project to elucidate how the various influences combine to create the present state.

The passage of the Japan tsunami was captured in our monitoring instruments in the Bay and the surface current mapping system installed to measure coastal circulation in the coastal region captured the first ever measurements of tsunami-generated currents approaching the shore after traveling across the Pacific Ocean.

Marine laboratories are in a constant state of transition. There is the anticipation of new arrivals and the sadness of departures, the excitement of new projects and new discoveries, and the satisfaction of completing programs. These local events occur within the context of the many changes occurring in the environment.

Last spring we celebrated the graduation of seven graduate students and three undergraduates. This fall we welcome 10 new graduate students and look forward to more undergraduates conducting their student research at RTC. Scott Kern has joined our facilities staff and Jose Flores has moved over to become our IT consultant responsible for keeping all the computers functioning. In June we celebrated Dennis Huggins’ retirement after 27 years serving RTC.

We are sad to see our Operations Director, Linda Mayo, leave for a new position on the east coast, but we wish her all the best. Also leaving us is the Sea Lion Bowl, but it’s not going far. It will be hosted by the Center for Science and Math Education on the main campus, and RTC staff and students will still be involved.

This year our open house, Discovery Day, is moved to later in October so that we can participate in the larger week long Bay Area Science Festival. Please mark October 30 on your calendar to attend Discovery Day.

All these events demonstrate the excitement and vitality of our environmental research facility. Please enjoy this *bayside* issue to learn about the many other activities not mentioned here, and please come visit the Center, we are here for you.
The invasive Algerian sea lavender (*Limonium ramosissimum* subsp. *provinciale*) in a salt marsh at Coyote Point Marina, San Mateo, CA. It was first discovered in SF Bay area marshes during an RTC wetlands class. See the story on page 13. Photo: Gavin Archbald

While seemingly simple, tunicates are actually more closely related to humans than any other invertebrate! In their tadpole-like larval stage, they have structures that are precursors to the backbone and spinal cord. They lose these features during their radical metamorphosis from larval to adult form. Learn more on page 6. Photo: Beth Sheets

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continued from cover... activity and wastewater treatment plants, environmental contaminants, changes in the food web supporting these fish, competition from introduced species, and predation by native and introduced fishes.

In 2008 the US Fish & Wildlife Service issued a Biological Opinion for the continued operation of the large water projects, focusing on their impacts on delta smelt. The Opinion concluded that increased freshwater diversion from the Sacramento-San Joaquin Delta during fall may jeopardize the long-term survival of delta smelt. The Biological Opinion calls for increases in flow into the estuary in fall, and also calls for a long-term study of the effects of fall flows and salinity patterns on delta smelt.

In response to the Biological Opinion, the Interagency Ecological Program for the San Francisco Estuary (IEP), a collaboration of nine state and federal agencies, has started a three-year Fall Habitat Study. This study is intended to further investigate the causes of the species’ decline and provide scientific information needed to develop ways to reverse it.

Three RTC research groups are collaborating with IEP scientists to conduct key aspects of the Fall Habitat Study. The overall effort is led by Dr. Wim Kimmerer in collaboration with Drs. Jonathon Stillman, Richard Dugdale, Frances Wilkerson, Alexander Parker, Lindsay Sullivan, and Nate Miller, along with a host of graduate and undergraduate students and technical assistants. Overall, the research is aimed at understanding the limits on the food supply to delta smelt. The investigations cover various levels in the ecosystem, including flow patterns and salinity distributions, nutrients, phytoplankton, zooplankton, and delta smelt, as well as jellyfish and overbite clams, both potential competitors for food with delta smelt.

To determine the extent of the low salinity habitat and how it changes with freshwater flow, and to investigate how organisms may take advantage of tidal flows to maintain their position within the San Francisco Estuary, Dr. Kimmerer is collaborating with Drs. Edward Gross and Michael MacWilliams on a numerical model to simulate the movement of water and food organisms in the delta smelt’s habitat. The mathematical hydrodynamic model improves on previous versions by using variable sized cells so that the model can more accurately represent the entire estuary, from the small channels of the Delta all the way to the open ocean. Tides, river flow, and winds force the model. Simulated particles representing plankton and small fish are assigned different behaviors and released into the model to investigate possible responses. The results will be compared to the measured distributions of water velocity and of organisms previously recorded in the field. This modeling work is integral to efforts in understanding how changes in freshwater flows affect the distribution of food organisms and therefore the feeding environment for delta smelt.

The concentrations of various mineral nutrients in the water are important for their effects on the growth of phytoplankton and other plants. Nutrient levels in the Delta are measured monthly by the Department of Water Resources; but until recently little emphasis had been placed on nutrient concentrations because they were almost always high. Drs. Dugdale, Wilkerson, and Parker are investigating the distribution, concentration and fate of nitrogen nutrients in the Sacramento River and low salinity zone. Two different forms of nitrogen, ammonium ($NH_4^+$) and nitrate ($NO_3^-$), are hypothesized to support the growth of different phytoplankton species, which in turn could affect the growth of zooplankton. Ammonium is released from wastewater treatment plants, and bacteria turn ammonium into nitrate in a process called nitrification. A single wastewater treatment plant on the Sacramento River discharges approximately 15 tons of ammonium nitrogen per day. Since the Sacramento River provides the vast majority of freshwater flowing into the estuary,
wastewater operators rely on dilution and nitrifying bacteria for continuing treatment in the river. In the first year of the study, Dr. Dugdale and his colleagues developed a protocol to precisely measure nitrification in the water column of the estuary. Dr. Parker is leading surveys on the Sacramento and San Joaquin rivers and the northern estuary to determine nitrification rates and the distribution and fate of ammonium and nitrate in comparison with other seasons.

Dr. Parker is also directing research to understand the dependence of productivity (phytoplankton growth) on nutrients and light in the Sacramento and San Joaquin rivers. The research team is comparing nutrient chemistry, phytoplankton biomass, productivity, and uptake of nitrate and ammonium in the Sacramento and San Joaquin rivers, and investigating the role of turbidity (water clarity) in phytoplankton productivity and nutrient uptake. The research team, sailing on the R/V Questuary, samples four times per year in September and October along the two rivers west to San Pablo Bay. Experiments are being conducted at RTC to investigate the response of phytoplankton to manipulated light and nutrient levels.

The next level in the food web being investigated in this study are the zooplankton, which consume phytoplankton and other small organisms. In the Delta, copepods are the predominant zooplankton and the principal food source for the delta smelt. The most abundant copepod, the introduced *Pseudodiaptomus forbesi* was partially replaced in 1993 by another introduced copepod, *Limnoithona tetraspina*, which may be too small to be suitable as food for delta smelt. A project run by the Kimmerer Lab is investigating interactions between these copepods. Of particular interest is how freshwater flow alters interactions between copepod species, specifically competition for food, and how these interactions affect the abundance of suitable food for delta smelt. Experiments using naturally occurring food will link quantity and quality of food to reproductive and development rates, allowing researchers to assess diet overlap between the two copepod species. Graduate student Karen Kayfetz will conduct the diet overlap experiments. She was awarded a grant to use a FlowCAM, a sophisticated instrument that can count, measure, photograph, and even identify particles the size of copepod food. Growth and development rates of these copepods in various locations are also being studied to determine whether competition is having an effect on survival.

Dr. Kimmerer’s Research Associate, Dr. Sullivan, is coordinating three projects on delta smelt and a potential competitor. Food limitation and fish behavior experiments are conducted at the UC Davis Fish Conservation and Culture Lab in Byron, where larval and juvenile delta smelt are placed in containers with different numbers of the two species of copepod. Their ingestion and oxygen consumption rates will be monitored to determine growth and development rates. This question is important for understanding whether the smelt have the food resources they need to thrive. Their prey consumption, as well as responses to changes in turbidity and presence of predator stimuli, will also be determined. Intern Sean Rohtla, a recent high school graduate, is assisting Dr. Sullivan in this research.

At the same level in the food web as the delta smelt are invasive or exotic species that compete for the same food reserves. Jessica Donald, a graduate student with Dr. Kimmerer, is studying the diets and spatial distributions of three species of invasive jellyfish. *Blackfordia virginica*, *Maeotias marginata*, and *Moeris alyonsi* all come from the Black Sea. Donald samples four shore-based stations, taking samples with nets and buckets from piers, and nine on the estuary, where water and plankton are collected on board the R/V Questuary. Water is filtered on board to extract chlorophyll, later measured in the lab to estimate the abundance of phytoplankton. The jellies are preserved, counted, identified, and measured, and their diet is examined. In addition, Donald is rearing all three species in the lab for experiments to determine feeding rate and abundance data. The results will yield an estimate of their impact on the delta smelt’s food availability.

The overbite clam, *Corbula amurensis*, has been implicated as another competitor for food, contributing to the delta smelt’s decline. These clams live in brackish to salty water, and die back where the water remains fresh for a long period during winter-spring storms. However, the copepods and other planktonic organisms move with the water, so the interaction between the clams and plankton depends on the clams’ response to salinity. A research team under the supervision of Dr. Stillman, with Dr. Jan Thompson of the US Geological Survey, is investigating how the metabolism and physiology of clams varies at different salinities. Postdoctoral researcher Dr. Miller is coordinating this investigation along with graduate students in the Stillman Lab. Research began in October of 2010 to establish baseline information. Aboard the R/V Questuary, the team collects samples monthly at four sites from Martinez up through Suisun Bay and into the lower Delta where the salinity varies with the season and tides. At each site, a sediment sample is obtained from the bottom and sieved to obtain 50 to 150 clams. It is a messy and labor-intensive process that can take more than a dozen sediment samples at sites with low clam populations. The food requirements, health, and growth of the clams are the data that will help determine how clams respond to changes in salinity, allowing the researchers to understand the influence of varying flow and salinity on the interaction among clams, plankton, and ultimately delta smelt.

The IEP Fall Habitat Study is an excellent example of a community of scientists, students, and staff working together to solve complex environmental problems. Research conducted in this study will not only help to understand and manage the decline of the delta smelt, but also provide critical scientific information to help improve management of the whole San Francisco Estuary.
In June, Vanessa Guerra and I traveled to the Bocas del Toro Research Station, a part of the Smithsonian Tropical Research Institute in Panama. The “Bocas” station is developing a program sponsored by the National Science Foundation’s Pan-American Advanced Studies Institute (PASI) to train emerging scientists in the field of tropical taxonomy - the classification of organisms. Courses at the station include the study of various sponges, algae, corals, and crustaceans. Vanessa and I both study invertebrates known as tunicates in our research and we participated in the Advanced Tunicate Biology course offered at the station this summer.

The course brought experts from around the world in many disciplines of tunicate biology. The first week was spent on an introduction to tunicate taxonomy, which is challenging due to the difficulty in distinguishing physical differences between species. We explored several habitats around the region’s islands, including mangrove islands, coral reefs, and marinas with artificial structures, to collect a diversity of tunicates. The Bocas region is considered one of the most diverse areas for tunicates in the Caribbean. Around 60 species have been found so far, representing 40% of the total known number in the Caribbean.

The remaining weeks of the course offered lectures on a variety of topics, including evolutionary biology, population genetics, invasive species, stem cell biology, regeneration, and feeding and digestion. Each lecture was followed by a lab where we learned different techniques for studying these subjects. Participants of the course also held evening seminars on their research covering broad topics of tunicate biology. Course participants came from the USA, Canada, Mexico, Brazil, Argentina, Chile, Colombia, Spain, South Africa, Singapore, and Japan. It was an incredible experience to develop relationships with other scientists from all over the world that are researching such diverse aspects of tunicate biology.

The last week of the course allowed participants to conduct independent research projects. Vanessa and I were interested in the presence of cryptogenic species in two different marinas and in mangroves adjacent to those marinas. Cryptogenic species are those whose origins are unknown; there is no evidence to support either a native or introduced origin. The first comprehensive tunicate survey was conducted in 2003, so many species found in Bocas are considered to be cryptogenic. Marinas are highly prone to species introductions from boats carrying organisms either in the bilge water within the hull, or clinging to the exterior. Marinas may act as stepping-stones for non-native species to move from artificial structures to natural habitats. It is important to establish baseline data for the region in order to monitor for new species introductions and for the potential spread of a species.

We were interested in two questions. (1) Does the presence of cryptogenic species on mangroves adjacent to a marina vary with distance from the marina? (2) Are cryptogenic species shared between a newer marina (two years in existence) and an older marina? After conducting surveys via snorkeling, we found that cryptogenic tunicates decreased in abundance the further away a
Above: The main laboratory building of the Bocas del Toro Field Station. Below: Vanessa Guerra snorkeling on a coral reef. Photos: Beth Sheets

mangrove site was from a marina. We also observed several cryptogenic tunicates shared between both marinas.

Our findings were very preliminary, but further monitoring efforts are currently being undertaken in Bocas, and future PASI course participants and researchers can continue developing baseline data for this area. Vanessa and I both greatly enjoyed our experience in Panama and learned so much. The course was an incredible resource for us to develop our understanding of tunicates and also gave us the opportunity to form relationships with other scientists across the globe. We encourage any other students interested in developing their taxonomy skills to apply to future PASI courses at the Smithsonian’s Bocas del Toro Research Station.

Beth Sheets and Vanessa Guerra are graduate students in Dr. Sarah Cohen’s Evolutionary Ecology Laboratory. Beth received her bachelor’s degree from the University of Alabama at Birmingham. Beth is currently using a genetic approach to investigate patterns of invasion of a colonial tunicate on the Pacific coast of North America. Vanessa received her bachelor’s degree from Humboldt State University. She is currently studying how American populations of an invasive solitary tunicate are connected.

RTC is excited to participate in the first Bay Area Science Festival (BASF). The BASF is a 10-day series of events designed to showcase the region as an international leader in innovation.

The goals of the BASF are to raise awareness of the importance of science, technology, engineering and math (STEM) in our local communities. The events are geared to provide access to every Bay Area resident to the region’s vast STEM assets by moving it into our local communities, creating an opportunity for meaningful and direct interactions with scientists and to engage young people in the fun, excitement and awe of science to inspire them to careers in STEM fields. Events will also encourage partnership and collaboration between and among the STEM community and Bay Area residents.

RTC’s 22nd annual Discovery Day is Sunday, October 30 from 11:00 am to 4:00 pm. Please note that our event is a little later in the month than usual in order to join in the BASF festivities. Our theme is “Sharing Science with Family and Friends.” Not to be confused with RTC’s annual Discovery Day, there are three other Discovery Days during the festival hosted by other institutions. The first is Saturday, October 29 at Cal State East Bay, one of our sister campuses in the 23-campus CSU system. The North Bay Discovery Day is Saturday, November 5 at Infineon Raceway, and RTC will host a hands-on, fun-filled science booth. A final Discovery Day is at AT&T Park on Sunday, November 6 where SF State’s College of Science & Engineering will host an interactive science booth. Please join us as we celebrate science in the Bay Area! For more information about the BASF and associated events, please visit www.bayareascience.org/
On first blush, the RTC campus may appear to be little more than a disparate collection of well-aged structures and odd artifacts that have borne the weathering impact of decades of waterside exposure. But just beneath the surface, there is a stark juxtaposition, with state-of-the-art technology and the vibrant culture of one of America’s premier marine research institutions. The aging infrastructure and artifacts present challenges, but also unique opportunities.

Too often the easy solution to aging infrastructure is to scrape and re-build. As time passes and new structures rise, the rich histories of our most important facilities become distant memories or ever smaller segments of our communities. The RTC campus is truly a unique and historically significant site in the Bay Area. Today, in its use as an increasingly sophisticated and bustling academic and research campus, a strong emphasis is being placed on moving forward, while honoring the site’s historic contributions.

The campus began as a fish packing plant, then became a Navy ship coaling station. Roebling & Sons Company used the site for Golden Gate Bridge cable construction, it was a nautical training school in the 30s, the Navy Net Depot during WWII, and the Minerals Management Service was on site in the 50s. In the 60s it was the National Marine Fisheries Service’s Southwest Fisheries Center, and SF State’s marine research facility was established in 1977. The main research building was once a warehouse, historic barracks now house Marine Operations and the Center’s machine shop, the Commanding Officer’s residence is a guest house, and the Officer’s Club is now the Bay Conference Center.

But more than just buildings have been repurposed. Readily visible along the seawall are multiple four ton blocks of concrete running its length, artifacts of the site’s WWII era activities. The blocks, with their steel hooks attached, are the weights that the Navy made on site when the facility was used for the construction of anti-submarine and anti-torpedo nets. The tarmac area is checkered with small steel plates, once the template for forming the massive nets. Just off the sea wall, rising out of the bay waters are more concrete structures, caissons from the wharf the Navy built in 1906. Several of these caissons have been repurposed as the base of RTC’s monitoring pier, which houses critical equipment that measures and reports real-time bay water conditions.

Central to RTC’s goal of incorporating and preserving the site’s historical character is the hiring of a new leader for the RTC facilities team, Scott Kern. With over 25 years of construction experience – and a specialization in rehabilitating older structures – Kern brings a dedicated eye to preservation and an artisan’s touch for creatively repurposing the artifacts that mark the site’s history. His creativity has led to a number of improvements on site using materials at hand. As one example, he repurposed the original roadside guard rail system (7” x 7” x 5’ concrete pilings) and constructed simple, but elegant, in-ground stairs that connect footpaths between the site’s upper and lower campuses.

Says RTC Director, Toby Garfield, “Our recently completed site development plan stresses the importance of weaving the complex history of the site into our ongoing efforts to build a facility that supports our educational and research mission.” Garfield’s interests include rebuilding the research wharf deconstructed by NMFS after a fire, completing the renovation of Building 36 with additional labs and classrooms, and bringing the old auditorium back to life. To realize these important and ambitious goals, Garfield, the University Advancement Office, and RTC’s College of Science and Engineering are diligently working to launch a successful fundraising endeavor. For more information on these and other strategic efforts to advance RTC’s mission, please visit rtc.sfsu.edu/ or call (415) 338-6063.
A Job Well Done!  After working 27 years at the same job, could you remember what your first project was? When asked that question, Dennis Huggins, RTC Facilities Maintenance Mechanic, smiled and said, “The Director, then Dr. Michael Josselyn, asked me to box up the books in several bookcases and then move the bookcases from the third floor to the first.” An easy task if you have an elevator and coworker, but Dennis had neither. Instead he came up with a system of ropes to lower the bookcases over a railing to the ground floor. He carried a few boxes of books down, then left the rest at the top of the stairs and requested the small group of scientists working at RTC in 1984 to help. “If you are coming down from the third floor to the first, grab a box and take it with you,” he told them. Dennis recalls that even the Director pitched in.

It is that kind of ingenuity that characterized Dennis’ work ethic. When he started working at RTC, he embraced the overwhelming job of being the only facilities staff person for a 28-acre center with multiple buildings. Over the years, Dennis has completed thousands of projects. You name it, he’s done it: construction, moving, painting, mechanical, electrical and plumbing. He’s also a master of tent assembly, a skill so necessary for our annual open house, Discovery Day. What were some of his favorite projects? His response, “the ones needed for scientific research.” He constructed incubators for ocean-going research cruises. He built a room for turtle research. When that project was complete he remodeled the space, filling it full of aquaria and all kinds of electronic equipment for raising coral and crabs. Another proud accomplishment was building a laboratory for our chemical oceanographer, Dr. Tomoko Komada. He has kept things running and made RTC a better work place for scientists and staff alike.

Being a great employee is just one reason why the RTC community appreciated Dennis. The other reason, he’s a people person. He’d always greet you with a good morning and a smile. Whether you were a Ph.D. Scientist or undergraduate student, if you had a project and needed help, Dennis was there for you. That was his recipe for success.

On June 30, RTC hosted a retirement party to celebrate and thank Dennis for his many years of service. Luckily for RTC, it was not a final farewell. Dennis has decided to ease himself into retirement and after less then a week, he showed up at RTC and signed up to be a part-time volunteer.

Thank you “Huggy Bear” for your dedication and hard work! The RTC community appreciates all you have done for RTC and we are so glad you’ve decided to stay around a little longer.


Rising Sea Levels: Moving Marshes

Sea level at the Golden Gate Bridge is currently rising at a rate of three mm, or about one tenth of an inch per year. Estimates project an increase of between 50 to 140 centimeters (20 to 56 inches) by 2100. However this rise may prove far higher and faster than these predictions. Under the most conservative (and optimistic) of estimates, the tidal marshes within San Francisco Bay will be flooded more frequently and more deeply during high tides.

Tidal marshes are wetlands where plants thrive in muddy soil that is regularly flooded during high tides and exposed to air during low tides. About 80% of San Francisco Bay’s tidal marshes have already been destroyed or altered by people. The remaining marshes filter sediment from the water, provide essential habitat for endangered plants and animals, and act as nurseries for many commercially valuable species, such as herring, salmon, and Dungeness crab. Tidal marshes are incredibly dynamic ecosystems and they can adapt to rising sea levels in many interrelated ways; one of those ways is by moving uphill.

The projected increase in water levels has the potential to drown the marsh. Currently, most tidal marshes are entirely flooded only on the highest high tides of the year (aptly named the King Tides; see photo). As sea level rises, the marshes will be entirely flooded more frequently. As individual marsh plants spend more time underwater, they are more likely to die. Plants living in the lowest areas of the marsh, where the marsh meets the Bay’s open waters or mudflats, will be the first to die. As plants on the edge die back, the marsh will shrink. Plants in the drier uplands will begin to be occasionally flooded by salt water, killing them as well. Marsh plants growing on the upper edges will quickly spread, moving to higher ground and reestablishing the ecosystem. Thus, a marsh has the potential to effectively move to higher ground.

At Rush Ranch, the National Estuarine Research Reserve (NERR) site in Solano County, the current marsh system is surrounded by gradually sloping pastures. As sea level rises, the tidal marsh at Rush Ranch can grow and spread into those pastures. However, most Bay marshes are surrounded by levees and bordered by developed areas that prohibit them from adapting to the changes in sea level. There are, however, some marshes that could move upland, if levees were removed. For example, some tidal marshes surrounded by levees are adjacent to recreational fields and farmland. Scientists are working to identify and restore high-priority areas so that they can become the Bay’s new tidal marshes. The next step is encouraging individuals and non-profits to purchase, protect, and restore these critical lands so that the Bay’s marshes have room to move.

RTC & SF Bay NERR
Fall 2011 Teacher Workshop
“Sea Level Rise”

Network with local educators and scientists as you learn about the latest research related to climate change and sea level rise.

Saturday, October 1
8:30 am to 5:00 pm

Breakfast and lunch are provided.
Register online: www.sfbaynerr.org
Highlighting RTC Student Scholarships, Awards & Achievements

Congratulations to RTC’s amazing undergraduate and graduate students! RTC students are awarded an average $60,000 in total scholarships annually. Awards and achievements for the 2010-11 academic year are listed below:

Gavin Archbald (Boyer Lab) was awarded RTC’s William Atchley Environmental Stewardship Award and RTC’s Paul F. Romberg Award for Service • Brian Bill (Cochlan Lab) was awarded a College of Science and Engineering (COSE) Graduate Student Award for Distinguished Achievement and an IRA travel grant ($340) • Brittaney Bjelde (Todgham Lab) received a Department of Biology Arthur Nelson Graduate Scholarship ($1500) and a CSU Council on Ocean Affairs, Science, and Technology (COAST) Graduate Student Award for Marine Science Research ($1500) • Sarah Blaser (Wilkerson Lab) received a COSE Graduate Student Award for Distinguished Achievement • Sara Boles (Todgham Lab) received a COAST Graduate Student Award for Marine Science Research ($1500) • Christina Buck (Dugdale/Wilkerson Lab) was appointed as a CSU Pre-Doctoral Scholar, also known as Sally Casanova Scholars ($3000), and received a COAST Graduate Student Award for Marine Science Research ($1500) • Hayley Carter (Stillman Lab) received an RTC SF Bay Scholarship ($500) • Lina Ceballos (Stillman Lab) received a Maxwell Scholarship ($4000), and a COAST Graduate Student Award for Marine Science Research ($1500) • Autumn Cleave (Boyer Lab) received a COAST Graduate Student Award for Marine Science Research ($1500) • Carrie Craig (Cohen Lab) was selected for a National Achievement Rewards for College Scientists (ARCS) Scholar Award ($10,000) and a COAST Graduate Student Award for Marine Science Research ($1500) • Tricia Goulding (Cohen Lab) received a COSE Graduate Student Award for Distinguished Achievement. She won first place for her presentation at the Systematics Conference in London for her work on mole crab parasites. In March she presented her masters research at the Northern California Society of Parasitologists meeting, held at RTC. Goulding was awarded the Balamuth-Horen Award ($100) for her talk on geographically widespread sandy beach fauna. She was awarded a COAST travel grant ($700), and is the first recipient of RTC’s new James Kelley Award for Academic Achievement • Vanessa Guerra (Cohen Lab) was awarded the TRaining in Ecology and Evolution (TREE) Fellowship, and was accepted to the Smithsonian Tropical Research Institute Advanced Tunicate Biology course in Panama. She received travel funding from the Smithsonian ($800) • Dave Hurt (Stillman Lab) was awarded a NSF Graduate Research Fellowship • Chris Ikeda (Cochlan Lab) received a COAST Undergraduate Student Award for Marine Science Research ($2500) • Karen Kayfetz (Kimmerer Lab) was awarded the first-ever FlowCAM Student Equipment & Travel Grant ($4500) and will receive a FlowCAM imaging flow cytometer to aid in her research, and travel support to the next ASLO meeting • David Lake (Cohen Lab) presented his masters research in March at the Northern California Society of Parasitologists meeting, held at RTC • Jeff Lewis (Boyer Lab) received a COAST Graduate Student Award for Marine Science Research ($3000) • Kristine Okimura (Carpenter Lab) has been accepted into the NSF funded CCB FEST classroom partnership program at SF State • Adam Paganini (Stillman Lab) received a Tyee Foundation scholarship ($1000) • Gwen Santos (Boyer Lab) received a COAST Graduate Student Award for Marine Science Research ($1500) • Rosa Schneider (Boyer Lab) received a Graduate Student Award for Marine Science Research ($3000) from COAST, a Department of Biology Arthur Nelson Graduate Scholarship ($1500), a Northern California Botanists Research Scholarship ($1000) and received a Maxwell Scholarship ($4000). Additionally, Schneider was awarded a 2-year Graduate Research Fellowship ($40,000) from the National Estuarine Research Reserve System • Beth Sheets (Cohen Lab) was accepted to the Smithsonian Tropical Research Institute Advanced Tunicate Biology course in Panama. She received travel funding from the Smithsonian ($800). She received a COAST Graduate Student Award for Marine Science Research ($1500) • Ariel Tang (Cohen Lab) received a SF Bay Scholarship ($500) and an IRA travel grant ($340).
Recent graduate Gavin Archbald has been part of the RTC community for many years. He started as an undergraduate student with wetlands ecologist Dr. Katharyn Boyer. He continued on as a graduate student in the Boyer Lab, while getting involved in outreach, sustainability efforts, and caretaking at the Ohrensahl Guest House. He spearheaded native plant removal and garden construction at the guest house, creating a whole new environment for visiting scientists and interns. We were able to catch Gavin between his many activities for this interview.

What inspired your interest in wetland science? Dr. Kathy Boyer. I took her Restoration Ecology course the first semester I attended SF State. I was interested in habitat restoration in general, but the course focused on wetland restoration and I came to realize how functionally important and impacted wetlands are. Subsequently exploring marshes around the Bay, I saw for myself how dynamic, beautiful and neglected marshes are. I see tidal wetlands as this amazing, often-forgotten wilderness in the Bay Area’s collective backyard.

What brought you to RTC as an undergraduate student? When I decided to go back to school for a second baccalaureate degree I wanted to learn as much as I could and not go broke as a student; so I looked for paid work in the Biology field as soon as I came to SF State. Dr. Boyer had recently been funded to work on eelgrass restoration in the Bay and I joined her team as a Student Assistant. I remember being blown away that RTC existed and immediately felt like it was a special place to be.

What did you study as a graduate student at RTC? I studied the ecology of an invasive wetland plant new to SF Bay marshes - Algerian sea lavender (Limonium ramosissimum) - which Kathy and another Boyer Lab graduate student, Amelia Ryan, identified growing in Strawberry Marsh in Mill Valley. No one knew the extent of the invasion in the Bay, how quickly populations might be spreading, and what factors promote or limit the plants’ spread in the Estuary, so I focused my thesis work on finding answers to those questions using field and greenhouse studies. I also worked for a year as a Graduate Fellow for the South Bay Salt Pond Restoration project developing tools to find Algerian sea lavender in the South Bay using modeling and remote sensing.

What do you like to do when not doing research? Lately, I have become enamored with gardening and native plant cultivation. I grew weeds during my thesis so growing native and edible plants is a nice change.

You became very involved in many aspects of the RTC community. Tell us about those contributions. I served for a year as RTC Student Association President, during which I coordinated the 12th Annual Conservation Biology Symposium, where students and professionals from around the Bay presented research related to Bay Area conservation science. I worked with RTC staff and volunteers to develop a website for RTC’s Sustainability Program and contributed an article on the program to the 2010 bayside. I volunteered as a Rules Judge and Moderator for the Sea Lion Bowl and have helped on assorted projects around RTC to help keep the place in good order. I really value having had the opportunity to contribute to a community of people with a common vision focused around environmental science, stewardship, and education.

What will you do next? I’m helping with the management of SF Bay wetlands as an independent contractor. I’m working with the SF Bay NERR (National Estuarine Research Reserve) to plan remote sensing and GIS data collection to monitor the effects of sea level rise on the marshes at China Camp and Rush Ranch. I’ve also continued to work with the South Bay Salt Pond Restoration project under Fullfrost and Associates, developing methods to map vegetation around the ponds using satellite imagery. In the coming years I plan to continue work on wetland restoration projects, buy a home in the Bay Area, and get involved with the urban farmsteading movement.

What did you enjoy most about being at RTC? Aside from the physical beauty of the place, I enjoy being part of a proactive, larger process. We are building knowledge to enable solutions to environmental challenges. It’s inspiring to feel like in some small way I’m part of the solution.
Green Report

Wetland Science Series Surprise

The San Francisco Estuary has the unfortunate distinction of having the greatest number of invasive species of all estuaries in the continental US. But that unfortunate fact makes it the perfect place for a class focused on invasive organisms. An expert in wetland invasive species, RTC’s Dr. Katharyn Boyer is the lead instructor of “Ecology of Invasive Species in Tidal Marshes of San Francisco Estuary.”

The course concentrates on species, plant and animal, that have invaded tidal marsh habitats and adjacent channels and mudflats in the estuary. Students examine mechanisms of invasion and identify taxa of greatest concern in current and future invasions. The effects of invaders on the ecology of the estuary’s marshes are discussed, as are modifications to habitat, changes to community structure, and influences on ecosystem processes. Also covered are current efforts to prevent further introductions, and methods for monitoring the distribution and abundance of invaders.

In August of 2006, Dr. Boyer taught the course for the first time. She was joined by co-instructor Dr. Chela Zabin, then program manager for the Smithsonian Environmental Research Center. As luck would have it, the field site they chose for the class had some interesting species to show the students, and a surprise in store. In addition to the predicted invasive plants and invertebrates, they discovered and reported a new one, Algerian sea lavender (Limonium ramosissimum).

Algerian sea lavender is a perennial, salt-tolerant plant of Mediterranean origin, in the same genus as a native Limonium, Limonium californicum. The invasive Algerian sea lavender is well established in many southern California salt marshes, where it is considered an aggressive weed. It is thought to have been introduced in San Francisco Bay by seeds transported through local watersheds from home gardens. Studies in San Francisco Bay wetlands have found it readily invades both restored and disturbed marshes - a serious concern since thousands of acres have been and will continue to be restored to tidal marsh in the coming years.

Due in part to the research done by recent RTC graduate Gavin Archbald (profiled at left), and efforts by the Bay Area Early Detection Network, the local Joint Venture, Bay Nature and several others, steps are being taken to inform the public of the problem and to help halt the spread of this invasive plant.

In addition to the class on invasive species, the RTC Wetland Science Series offers courses in wetlands delineation (both basic and advanced), restoration ecology, policy, geographic information systems (GIS), plant identification, experimental design, wetland restoration monitoring techniques, and statistical analysis. For more information visit http://online.sfsu.edu/~wetlands, email wetlands@sfsu.edu or call (415) 819-2073.

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Algerian sea lavender blooms. Photo: Gavin Archbald
In addition to the collaborative studies examining questions regarding delta smelt habitat, RTC scientists have secured funding to support other critical research:

**Boyer Laboratory**: Dr. Katharyn Boyer’s new grants focus on evaluating the extent and functions of native vegetation in the subtidal zone of the San Francisco Estuary. An award funded by the National Oceanic Atmospheric Association (NOAA), will support work to inventory brackish species of submerged aquatic vegetation (SAV), including widgeon grass (*Ruppia maritima*) and sago pondweed (*Stuckenia pectinata*). Similar to eelgrass (*Zostera marina*) in the central, saltier portions of the Estuary, SAV in the brackish (low salinity) regions such as Suisun Bay is likely to provide valuable food resources and cover for fish species at risk such as migrating salmon. However, little is known about the distribution and abundance of these SAV species. Dr. Boyer and her students will document and map these species using GIS (Geographic Information Systems) tools, helping to bridge the data gap and aid in NOAA’s management of submerged vegetation and associated fauna.

Dr. Boyer’s previous restoration and ecology studies of eelgrass have led to an additional award from the California Coastal Conservancy and US Environmental Protection Agency (EPA) for a Living Shorelines Project. Dr. Boyer will lead an interdisciplinary team to design, construct and assess the roles of restored subtidal habitat features including eelgrass and native oysters in several locations in the Estuary. The overall goal of the project is to restore these features in various configurations and evaluate their relative merit in providing habitat to birds, fish, and invertebrates, while also assessing their effects on physical processes (such as sediment erosion and buildup) important in a time of sea level rise and other effects of climate change. Dr. Boyer’s interdisciplinary team will include biologists, hydrologists and engineers. Collectively, they will work to develop recommendations for future restoration projects that will support vital biological, physical, and societal goals along the Estuary’s shorelines.

In addition, Dr. Boyer was contracted by another CSU campus, the California Maritime Academy in Vallejo, to ensure that an eelgrass bed was restored following dredging of their small boat basin. Dr. Boyer provided recommendations for methodologies and timing and designed a restoration plan. Following transplanting and seeding of eelgrass, Dr. Boyer and her team will provide annual monitoring of the restoration project.

**Cochlan Laboratory**: Dr. William Cochlan was granted a new ECOHAB (Ecology & Oceanography of Harmful Algal Blooms) award from the Interagency Research Partnership that includes several federal agencies tasked with studying and monitoring the ocean, such as NOAA, NSF, NASA, EPA, and the Office of Naval Research. This project examines the ecology and physiology of a Harmful Algal Bloom (HAB) phytoplankton species in a combined laboratory and field study in the Pacific Northwest where fish farms are often exposed to the menace of toxic algae. Recurring blooms of *Heterosigma akashiwo* have caused extensive damage to both wild and net-penned fish of Puget Sound, WA and are believed to be increasing in distribution and abundance throughout the region and elsewhere in the world, including their presence in SF Bay. The mechanism of *H. akashiwo* toxicity is not well understood, and over the next three years, Dr. Cochlan and his team of investigators and students from RTC, the Northwest Fisheries Science Center (NOAA), the University of Western Ontario and the University of Maine will conduct research to identify the primary toxic elements and specific environmental factors that stimulate the fish-killing *H. akashiwo* blooms. They hope to provide managers with the fundamental tools needed to help reduce the frequency and toxic magnitude of these harmful algal events. This summer the Cochlan Lab spent a month at the Friday Harbor Laboratories (University of Washington) on San Juan Island conducting field studies using a newly constructed mobile field lab, and continued their research at RTC on their return.
with the assistance of NSF-funded REU (Research Experiences for Undergraduates) student Itamar Gnatt. Their work is featured in a series of Facebook blogs, which were picked up by NOAA headquarters as a pilot for social media. Stories and videos are available at: www.facebook.com/HeterosigmaHABLab

Dr. Cochlan was also awarded a new US Department of Energy grant to study the environmental factors responsible for enhancing the lipid (oil) production of marine microbial algae. This project is designed to discover how the limitation of macronutrients such as phosphorus, silicon and nitrogen trigger the production of triacylglycerols (TAGs) by tropical and semi-tropical phytoplankton. TAGs are the essential precursors for biofuels that can be used in vehicles. Cochlan and all existing members of his lab have extensive experience in the very new algal biofuels industry through their involvement with Cellana LLC where Dr. Cochlan was Head of Cultivation and instrumental in the development of this newly-built research and pilot facility in Kailua-Kona, HI. Dr. Cochlan moved his lab to Hawaii from 2008 to 2010 before returning to RTC to continue laboratory-scale research critical to the continued success of the large-scale production efforts in Hawaii – the largest biofuel facility using marine phytoplankton in the USA. Their ‘green’ research was presented this summer at the First International Conference on Algal Biomass, Biofuels and Bioproducts, and is expected to continue for another two years with this federal funding.

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