AQUATIC & FISHERY SCIENCES

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SPRING '05

Aquaculture Research at SAFS

Historically, the School of Aquatic & Fishery Sciences (SAFS) has had a strong aquaculture research focus, rooted in attempts to improve techniques and production. In the 1990s, however, aquaculture research and instruction declined largely due to attrition of faculty specializing in related disciplines.

Several years ago, a SAFS committee was convened to address the future of our aquaculture program. The committee recommended that the program's emphasis change from food science and culture to the breadth of related core sciences including physiology, genetics, toxicology, and microbiology. These areas of study are now known collectively as "animal biology and culture."

SAFS students pursuing this focus need to be familiar with the role of aquaculture in fisheries, issues associated with shellfish and finfish culture, and the role of the environment in the success of culture operations. This knowledge is necessary to support sustainable culture operations as well as conserve and restore wild populations.

Our newest faculty member and Executive Director of the Western Regional Aquaculture Center, Graham Young (interview, page 2), underscores the importance of aquaculture research with a sobering fact: "It is no longer possible to meet global seafood demand with just wild fisheries."

Graham echoes the comments of others–"There's no going back." As we increasingly depend on aquaculture to supply global seafood demand, we must use the most talented minds to conduct the best possible science to help us succeed in meeting the need.

A list of current and recent projects (pages 3–4)—including studies on physiology and endocrinology, microbiology, disease, and hatchery supplementation—highlights aquaculture-related research being conducted at SAFS.

Jon Wittnick

Pictured are coho salmon fry being reared at the UW's research and teaching hatchery.

Aquaculture

Graham Young

Penny Swanson

Professor and Executive Director, Western Regional Aquaculture Center
Specialities: physiology, endocrinology, reproductive biology
BSc, 1975; PhD, 1980, Sheffield University
Focus: Brain pituitary control and reproduction

http://fish.washington.edu/young

Graham Young is from Liverpool, England. He joined SAFS last fall in dual roles: he is a faculty member and the successor to Ken Chew as Executive Director of the Western Regional Aquaculture Center (WRAC).

For his PhD work, Graham investigated pituitary ultrastructure to understand how environmental factors regulate reproduction via hormones in the sailfin molly, a species common in US east coast estuaries.

After earning his PhD, Graham went to the National Institute for Basic Biology in Japan, where he studied salmon ovarian cell biology. Then at UC Berkeley, he investigated developmental and growth processes in juvenile salmon. This basic work had a practical use in hatchery operations: finding the physiological markers that help determine when salmon peak in their ability to adapt to seawater.

After Berkeley, Graham spent 14 years at the University of Otago (New Zealand), where he developed advanced courses on reproduction and physiology. He used salmonids and eels as models for stress physiology and reproduction research, and studied growth and reproduction in marine fishes with aquaculture potential.

Graham's last stop before SAFS was at the University of Idaho, Moscow, where he continued his fish reproductive endocrinology work, and began studying the mechanisms that trigger puberty—specifically the timing of the first reproductive cycle. He said, "Knowing how to manipulate the timing of puberty is important in fish culture, not only for salmonids, but for sturgeon and other species. If you're culturing sturgeon for caviar, you can't wait up to 14 years for a female to produce eggs."

When the SAFS/WRAC job opened up, Graham couldn't resist the opportunity: "The timing was ideal, given that the School was seeking to strengthen areas like physiology and other disciplines that can be applied to aquaculture issues." Also, the many existing and potential collaborators in Seattle were a plus. Besides overseeing the WRAC program and conducting research, Graham will be developing a new flagship course in aquatic animal physiology for SAFS.

Graham pointed to his collaborations with ecologists and behaviorialists, work with the New Zealand/Australian aquaculture industry, and studies of basic growth and reproduction of candidate marine aquaculture species as strengths he brings to SAFS and WRAC. To the WRAC directorship, he brings a twist: "Coming from overseas made me beholden to no one; I can start with a clean slate, ask objective questions, and ensure we make the best use of the available resources."

Graham spoke to changes in how aquaculture research is perceived in academia: "Aquaculture is no longer viewed as a single discipline; it is an application of multiple disciplines." He said that originally aquaculture research had been directed at fundamental issues–reproducing in captivity, growing bigger fish faster–but as the industry grew, concerns about issues like environmental impacts, disease, and potential interactions with wild stocks also increased.

Graham applauds WRAC's expanded scope of research: "Several recent projects focus on environmental issues, ranging from eelgrass–oyster interactions to effluent control in trout farms." He characterized WRAC's modus operandi as conducting "strategic science" through addressing a mix of broad issues and very specific, regional concerns. He added that WRAC still supports tightly focused applied research, such as drug efficacy tests or improving systems for live haul of fish.

To address the increasing demand for seafood, the Department of Commerce set a goal to increase US aquaculture production fivefold by 2025. Graham said, "The challenge is to do this economically, efficiently, and sustainably." He is optimistic that, given the quality of scientific talent available and sufficient research funding, US aquaculture can grow in a responsible and sustainable way. He concluded, "We can do it right in the USA, or depend on seafood raised overseas where we have little control over sustainability or food safety."

Aqua facts

Sources include the United Nation's Food and Agriculture Organization, NOAA Fisheries, and the Pew Ocean Commission.

Global stats

- Global per capita seafood consumption averages approximately 30 pounds annually
- More than 70% of global fisheries are either fully exploited, overexploited, or depleted, and no increase in food from capture fisheries is predicted into the mid-21st century
- Harvests are already maxed out at less than 100 million metric tons per year
- As of 2002, about 30% of total global seafood production came from aquaculture operations, compared with 4% in 1970
- Total aquaculture production in 2002, including plants, was 51.4 million metric tons (US$60 billion)
- By 2030 aquaculture production will have to at least double to meet future demands

USA stats

- US per capita seafood consumption was 16.3 pounds in 2003, compared with Japan at over 150 pounds annually
- US aquaculture output represents about 1% of total global production
- About 40% of US seafood is imported—the largest trade deficit in the agriculture sector
- US aquaculture, dominated by freshwater catfish production, generates about $1 billion each year
- US aquaculture supplies about 10% of domestic seafood production compared with that from capture fisheries, but the value of aquaculture products is about one-third that for capture fisheries landings
- The total value of aquaculture production in the western region was over $174 million in 2001; trout, mainly from Idaho, and oysters constituted the bulk of this value

SAFS aquaculture-related research

Many non-SAFS researchers collaborate with our investigators on the following research projects. We acknowledge their substantive role in these studies.

Brain cholinesterase inhibition in juvenile chinook exposed to carbaryl in seawater—implications for the use to control burrowing shrimp

Principal investigator (PI): C. Grue, J. Grassley, W. Major, J. Cabarrus, N. Overmann, C. Curran

Support: SAFS, USGS, Washington State Commission on Pesticide Registration

Investigators are quantifying salmonid exposure to carbaryl, which is used to control burrowing shrimp in Willapa Bay oyster beds.

Captive rearing of pinto abalone for restoration and aquaculture development

PI: C. Friedman, K. Naish, K. Straus, B.Vadopalas

Support: Washington Sea Grant Program, Saltonstall-Kennedy (NOAA)

Besides field assessments and population genetic analyses, investigators are developing culture methods for restoring pinto abalone as well as evaluating the potential of this species for commercial aquaculture in Washington State.

Consequences of inbreeding in chinook salmon

PI: K. Naish

Support: Bonneville Power Association

Researchers are studying chinook to determine the degree of inbreeding beyond which a population experiences loss of fitness; they hope to compare the risk of inbreeding depression against other risks (e.g., domestication) and help formulate guidelines to determine if a captive broodstock or rearing program is warranted.

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Josh Davis

Undergraduate Nate Wright, sampling for a study of gametogenesis/ maturity-at-age in cultured intertidal geoduck clams.

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Eel migration and reproduction
PI: G. Young
In Southeast Asia and Europe, aquaculture of catadromous anguillid eels is a major industry that must rely on wild juvenile glass eels because captive breeding has never been routinely accomplished. Researchers are analyzing the mechanisms controlling adult metamorphosis and reproduction in New Zealand eels.

Endocrine control of fish growth
PI: W. Dickhoff, M. Shimizu, A. Pierce
Support: USDA Cooperative State Research, Education, and Extension Services (CREEES)
Insulin-like growth factor binding proteins (IGFBPs) and other hormones and growth factors affect how efficiently vertebrates like fish grow. Determining which IGFBPs inhibit or stimulate growth will help in designing diets or other measures to enhance fish growth in aquaculture operations.

Gametogenesis and the timing of puberty in salmonid fishes
PI: G. Young, B. Campbell, I. Nakamura, M. Kusakabe
Support: USDA-CSREES National Research Initiative, Japan Society for the Promotion of Science
Understanding how the development of germ cells and timing of puberty is controlled can help overcome reproductive problems in aquaculture. Researchers are investigating hormonal mechanisms controlling early gamete development, focusing on how critical genes are turned on and off.

Geoduck aquaculture
PI: C. Friedman, D. Armstrong, R. Hilborn, K. Naish, B. Vadopalas, C. Ma, C. Wheeler
Support: Washington Department of Natural Resources, SAFS
Investigators are assessing egg and sperm production potential of geoducks during their 6–7 year culture cycle to determine whether cultured geoducks interact with and reduce genetic diversity in their wild counterparts.

Immunological mechanisms of intensively reared warmwater and coolwater finfish
PI: C. Friedman, M. Purcell
Support: WRAC
To better understand salmonid and hybrid striped bass immune systems and how these species respond to infection, researchers are developing experimental reagents and assays to help aquaculture companies monitor fish health and immune function following vaccination.

Larval dispersal of pinto abalone
PI: C. Friedman, J. Bouma, B. Vadopalas
Support: Washington Sea Grant
Researchers are evaluating juvenile pinto abalone population dynamics and characterizing larval behavior and dispersal potential to improve evaluations of populations within the San Juan Island archipelago.

Locating the genes underlying development rate and growth rate in coho salmon: implications for conservation and aquaculture
PI: K. Naish
Support: Washington Sea Grant
Salmon conservation requires measuring the genetic consequences of domestication, supplementation, and inbreeding to fitness traits. Researchers are attempting to link genetic markers to such traits in coho. These markers can be employed as proxies to study genetic diversity relevant to the long-term survival of salmon populations.

Microbiology of larval rockfish
PI: R. Herwig, S. Chaiyapechara
Support: Royal Thai Government, SAFS, NOAA Fisheries
Microorganisms in the intestinal tract of larval fish affect survival, growth, and disease resistance. By studying larval rockfish microbiology, investigators hope to isolate and characterize bacteria for use as probiotics (microorganisms that can benefit host health).

Oxytetracycline optimization and endangered white abalone
PI: C. Friedman
Support: California Sea Grant
Investigators are optimizing the delivery of oxytetracycline for cultured red, black, and white abalone, and assessing depletion dynamics in foot and digestive gland tissues (a human health concern). They are also examining the efficacy of oxytetracycline to reduce bacterial loads and disease development (withering syndrome) in captive endangered white abalone in California.

Oyster herpesvirus
PI: C. Friedman, C. Burge; Support: National Sea Grant
Oyster herpesvirus may pose a serious threat to US oyster producers. Researchers are assessing this pathogen's impact on oyster populations and characterizing it relative to known members of the Herpesviridae family.

Physiological markers in salmonid peritoneal fluid composition
PI: G. Young
Support: Digital Angel Corporation
Nanotechnology may facilitate a passive integrated transponder (PIT) tag that can measure and report changes in fish physiology. When a fish experiences environmental stress, changes to the peritoneal fluid and gas within the cavity (the usual PIT tag location) may be used as biomarkers. Investigators are determining appropriate variables to measure in the peritoneal fluid.

Pre-spawn coho salmon response to pesticides in surface waters
PI: C. Grue, J. Hearsey, J. Grassley
Support: SAFS, USGS, Washington State Commission on Pesticide Registration
Researchers are studying the effects of exposure to pesticides in urban western Washington streams on the survival and reproductive success of pre-spawn hatchery and wild coho salmon. Results suggest other factors (water quality, habitat, or other contaminants) may effect mortalities.

Alumni
Where are they now?

From 1980 to present, SAFS has graduated an average of 24 BS, 20 MS, and 9 PhD students annually. The School has given students many of the critical skills and experience needed to follow diverse careers in education, research, and service. Whether pursuing their passions through teaching, conducting research, or working with management and policy makers, our alumni acknowledge the key role SAFS played in helping them to realize their dreams.

When our students leave these halls and embark on their careers, their relationship with SAFS doesn't necessarily end–it often continues long after graduation, with many of our alumni generously supporting our programs through ongoing financial and other contributions.

Recently, we have sought ways to better acknowledge the contributions of our alumni and other benefactors. In 2003, we started an annual awards ceremony in part to thank our many alumni and friends who donate to our graduate student endowments.

In this issue, we introduce an annual column to feature our alumni–where they have gone, what they are doing, and what insights they can offer from their experiences here and on the job. For our first column, we highlight CJ Casson, who works at the Seattle Aquarium.

Marcus Duke

CJ Casson (BS in Fisheries, 1980)

CJ Casson

BS Fisheries, 1980
Curator of Life Sciences, Seattle Aquarium

CJ Casson is a native of Washington. He spent his youth first in Shorewood and then on Vashon Island. Living on the beach, he spent much time in the water. CJ recalled, "We started a SCUBA club and made artificial reefs." Such exposure at an early age helps explain his lifelong passion for the sea.

A turning point in his life occurred during a break from college. CJ said, "I went to the newly opened Seattle Aquarium and something clicked." His search for the right skills and experience to work at the aquarium led him to SAFS (then the College of Fisheries): "It seemed the perfect fit," he noted, "I couldn't have gotten where I am without my training at Fisheries." While at SAFS, he also started volunteering at the aquarium. He remarked, "The day I graduated from UW Fisheries, the aquarium offered me a full-time job!"

At the aquarium, CJ had been Curator of Birds and Mammals since 1990, but last year he was promoted to Curator of Life Sciences. He described his job: "I ensure the animals are healthy, and I help design exhibits. But even more important, in my new position, I focus on helping everyone collaborate as a team."

CJ is a recognized international leader in sea otter research and care. His work has ranged from emergency sea otter recovery efforts following the Valdez Oil Spill in Alaska to consulting with aquariums and zoos around the world on marine mammal exhibit design, captive breeding, and animal husbandry. He played an important role in the Seattle Aquarium becoming the first aquarium to successfully raise sea otters to maturity.

On the day of our interview, CJ said: "This morning I got here at 6 am to feed the mother of our newest sea otter pup." He and other staff and volunteers are monitoring the pup 24 hours a day to track its development. The data recorded are used to compare behaviors with records of past, successfully reared pups, which he noted, "helps us see trends that might show potential problems before they become significant." CJ added, "Much of this I learned at Fisheries."

Besides serving the community with unique ways to observe the aquatic world, the aquarium plays an important role in research. Recently, it hosted its fourth international workshop on sea otter conservation. CJ said, "We invited people who work in aquariums, zoos, and governmental agencies, and wildlife biologists and tribal people to share their views.

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A model of cooperation: Pacific whiting research

Collaboration and cooperation are important aspects of the School's mission. Researchers at SAFS are involved in a study that exemplifies the spirit of cooperation among private industry, the government, and academia: The Pacific whiting industry, NOAA Fisheries' Northwest Fisheries Science Center (NWFSC) and Alaska Fisheries Science Center, and SAFS are working to conserve and manage the whiting resource, and the results stand to benefit all players.

The Pacific whiting fishery is the largest fishery off the west coast of the USA and British Columbia. Annual harvests and value average 250,000-300,000 metric tons and $20 million. Also known as hake, Pacific whiting is primarily used to make surimi for Japanese markets.

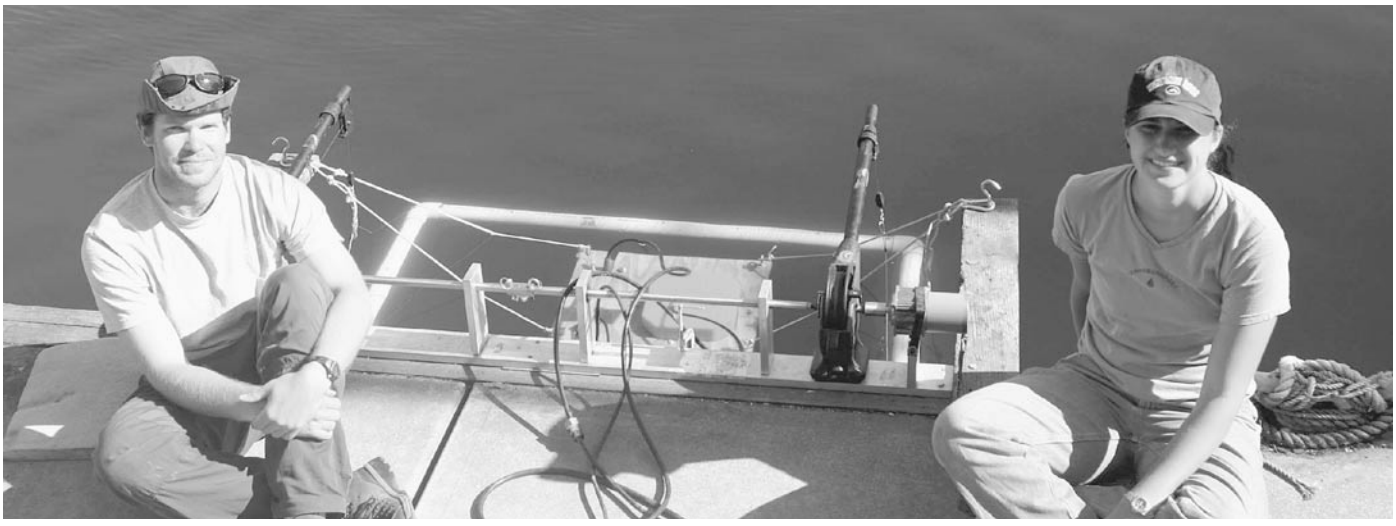
In 1997, the Pacific Whiting Conservation Cooperative (PWCC) was formed by four catcher–processor companies: Alaska Ocean Seafoods, American Seafoods, Glacier Fisheries, and Trident Seafoods. With PWCC's help, the fishery evolved from an Olympic-style race for fish to a cooperative emphasizing conservation. PWCC members voluntarily divided the whiting quota, which resulted in decreased bycatch and waste, better quality product, and reduced fishing effort. By 1999, the yield for surimi production had increased by 40% and bycatch, particularly yellowtail rockfish, was greatly reduced.

The PWCC sponsors research for the West Coast groundfish fishery. For example, PWCC collaborates with the NWFSC to collect abundance data for determining the long-term health of the whiting population. By reducing uncertainty in understanding stock dynamics and in underlying causes of stock abundance variation, this research will help improve fishery management.

In 2001, the PWCC funded a research program on fisheries acoustics at SAFS. Graduate student Mark Henderson and his advising professor, John Horne (SAFS) are investigating how Pacific Whiting reflect sound. (The collaborative nature of Mark's research is underscored by his thesis committee, which comprises Gordie Swartzman, also SAFS faculty; Guy Fleischer, NWFSC; and Vidar Wespestad, PWCC.) Acoustic echosounders, which use sound to survey abundance of fish stocks, are an important management tool, but there still remains much to learn about this technology and how to interpret the data it yields.

Mark seeks to understand why acoustic reflectivity or target strength data vary. Target strength depends on the size, orientation, physiology, and location of a fish in the acoustic beam. The more accurate the target strength measurements, the more accurate the abundance survey. Besides financial support, the PWCC has provided access to boats for sampling and has collected additional samples for Mark and John.

NWFSC scientists expect Mark's research results to directly affect the methods used to assess the status and trends in whiting. PWCC President Jan Jacobs (also Director of Government Affairs, American Seafoods) commented on this collaboration: "There have been some extremely interesting and valuable results. We are pleased with the progress and are confident this work will contribute to improvements in fisheries research and management."



John Horne

Mark Hendersen and technician Rachel Latham used a tilt frame (center) to measure whiting target strength.

Claire Horner-Devine

Research Assistant Professor

Specialities: microbial ecology, community ecology, diversity and ecosystem function, biogeography

BS, Princeton, 1996; PhD, Stanford, 2004

Focus: Patterns of diversity and community composition (ecology of diverse communities)

http://fish.washington.edu/horner-devine

Claire Horner-Devine joined the SAFS faculty in fall 2004. After earning her BS degree, Claire taught high-school biology and environmental studies, and designed a course that focused on drawing students into environmental science through social issues. Her students were interested in the role of diversity in providing ecosystem goods and services–processes and products of a functioning ecosystem that sustain and benefit human life. "For example," she said, "a healthy ecosystem can provide water purification, crop pollination, or soil conservation."

At Stanford's Center for Conservation Biology, Claire conducted PhD research on butterfly community ecology in a Costa Rican agricultural landscape. She sought to understand how forest patches and their surrounding areas—the "matrix," which includes human development and activities like agriculture—interact to support a diverse faunal community. Claire then shifted her attention to the ecology of microorganisms, in large part to address the issues that captivated her high-school students–how diversity is distributed and what the relationship is between diversity and ecosystem services.

"Microbes are responsible for many critical ecological processes, like decomposition, trace gas emissions, and nitrogen cycling," Claire said. "They represent the majority of biomass, diversity, and evolutionary history on earth." An issue that interests her is whether patterns and processes can be generalized across organisms. She elaborated: "Do patterns extend across all evolutionary history and all domains of life?"

Claire has used both small, contained freshwater ecosystems–"mesocosms"–and field sampling to study patterns and processes of microbial communities. She has studied how freshwater bacterial communities change over a productivity gradient, and examined the spatial distribution of bacteria to show that the number of microbial taxa increases with the sample area size, similar to most macroorganisms.

Claire's research has a practical side—determining whether natural systems can recover from disturbance. She cited three examples: One relates to the role of microbes in restoring ecosystems—can the present microbes restore ecosystem processes or must their composition change? Another pertains to dumping nutrients into aquatic systems—how does microbial composition determine system response to such anthropogenic pressure? And, on a global scale, how might climate change influence microbial communities and the processes they mediate?

Roger Fuller

Claire Horner-Devine (left) and Jennifer Hughes collect samples to study the spatial distribution of salt-marsh sediment bacteria.

Why focus on aquatic microbes? Claire answered, "We still have much to learn about microbial communities living in aquatic systems and the role they play in biogeochemical processes and food webs. Because microbial diversity may be lower in water than in soil, it may be easier to sample a relatively large part of the community and thus have a clearer window into community and population dynamics."

At SAFS, Claire plans to combine her mesocosm approach with field studies to examine the effects of climate change on aquatic communities, learn how microbial communities and processes change over time, and learn more about feedback between microbes and organisms in the context of invasions.

Claire sees excellent opportunities for interdisciplinary exposure at the SAFS–Oceanography Marine Molecular Biology Lab: "Someone working on bacteria can be right across the bench from someone working on sharks." She added, "I think the school and the college are hot spots on campus for evolutionary and ecological research."

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Aquarium research extends beyond the context of its facilities. For example, another SAFS graduate, Shawn Larson, is conducting endocrine and genetic analyses on wild stocks of sea otters. Recently, the aquarium embarked on a collaborative study with NOAA Fisheries and the UW to determine the movement patterns of sixgill sharks. CJ noted, "It's not a well-known species, so this is a great opportunity."

CJ observed that the aquarium's mission–inspiring conservation of our marine environment–also includes a strong educational element, citing last year's attendance of 40,000 school kids: "Many of them had never seen a Pacific spiny lumpsucker, or a grunt sculpin, or a sea otter pup."

CJ credits former director, Bill Arntz, with the aquarium's focus on connecting more personally with audiences. Now, staff trained in aquatic biology act as personal guides, and the aquarium is more immersive. For example, attendees are surrounded by tidepools they can reach into and touch. CJ believes the record-setting attendance last year was due to the new emphasis on human interaction.

CJ considers himself very lucky to have worked for the aquarium for so long–"I have this passion for the aquatic world, and they pay me to relate this passion to people!" He offered some advice for our upcoming scientists: "I couldn't have gotten my dream job without my time at Fisheries. The strong, well-rounded foundation I got at the school enabled me to relate to the diverse scientific disciplines pursued here. So I say, 'Follow your passion. Do what you love and be committed to it, and something will come your way'."

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Comments are welcome.

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