



California Agriculture

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**Racing for crab:
Sea Grant fishes for solutions**



W. R. Gomes
Vice-President
Agriculture and
Natural Resources

ANR Looks to the Future

When we began our last strategic planning review for the Division of Agriculture and Natural Resources (ANR) in 1997, California's economy was booming. The state was experiencing double-digit revenue gains, largely fueled by the high-technology sector, and UC saw its base budget increasing after the lean years of the early 1990s.

The Division also shared in new revenues during the boom times, with ANR research augmented \$1.5 million in 1997-1998 and Cooperative Extension's (CE) budget increased \$3 million between 1998 and 2000. As we entered the new millennium, we were planning for expansion in our CE advisor and specialist ranks and modest, but incremental growth in our research.

This changed suddenly and dramatically in early 2002 on news that a sharp decline in tax revenues would leave California facing a \$35 billion budget shortfall. As a consequence, UC lost nearly \$1 billion in state funds over the next 24 months; ANR saw its research program cut \$19 million (20%) and CE by \$12.5 million (25%).

Since ANR state funds mainly pay for salaries and benefits, the cuts caused significant reductions in administrative, field support and academic positions. In all, nearly 350 campus and systemwide positions were lost through retirements, layoffs and attrition, or will not be filled. We eliminated or consolidated a number of statewide programs, allocated temporary funds to salaries and benefits to avoid further layoffs and made deep reductions in administrative budgets in Oakland.

When the potential impact of the state budget crisis became clear in late 2002, the deans, other ANR leaders and I began the process of re-evaluating the scope of programs for ANR. We were determined to get a clear picture of available resources, short- and long-term, evaluate and identify the strengths and limitations of the Division, and change how we do business.

Our goal was to think more strategically about ANR. What should we look like in the future? How should we invest our limited resources? Where could ANR make a difference? Early on we recognized the value of fully involving external stakeholders and the ANR community in both an advisory and consultative role during these deliberations.

In spring 2003, we commissioned three studies that looked at organizing CE for the future, potential cost-recovery programs to augment CE funding, and options for improving the ANR statewide organization. The recommendations and findings from these reports were posted online to make them accessible to as broad an audience as possible.

In January and February 2004, we held five listening sessions across the state to solicit input from stakeholders, partners and ANR employees. More than 500 people attended these public meetings and their input, insights and recommen-

dations were invaluable. Several recurrent themes emerged.

Participants urged us to focus ANR programs and resources on high-priority issues; maintain county-based CE; improve coordination across campus, county and statewide programs; and increase opportunities for external stakeholder participation in ANR planning efforts.

I want to share our progress in focusing ANR programs and resources on high-priority issues. This recommendation was heard from our stakeholders at every listening session, and makes sense fiscally and programmatically given the budget cuts of the past 2 years. We realize we cannot continue to try to be all things to all people. We know that our options, over the short term, are somewhat limited without an infusion of new permanent state funding.

In the meantime, ANR's leadership will focus the Division's resources on programs where we can make the greatest difference. In September 2004, on the recommendation of the ANR Program Council, we adopted a set of priorities or core issues, which will be used in the short term for the allocation of discretionary ANR resources to fund competitive grant programs and other collaborative efforts. Over the long term, they are expected to influence hiring decisions for CE advisors and specialists and to further define ANR programs and priorities.

The Program Council identified and recommended 21 core issues they considered to be of the greatest relevance and importance to California's agricultural, natural and human resources sectors and appropriate to ANR's mission.

High-priority core issues are food safety, invasive species, pest management, sustainability and viability of agriculture, water quality and youth development.

Medium-priority core issues are air quality, biosecurity, human nutritional status, land use, obesity, organic production, soil quality, sustainable use of natural resources, waste management, water supply and allocation, and wildland fire.

Low-priority core issues are agricultural labor, community development, family and consumer well-being, and food security. The low-priority issues, while recognized as representing critical needs for California and important fields of endeavor for ANR, are areas where new investment of resources is not likely in the near future.

We are already using the core issues and priorities established by the Program Council as the basis for a new ANR competitive grants program announced on Sept. 15. The UC-ANR Core Issue & Target Opportunity Grants Program will allocate approximately \$800,000 in discretionary funds for collaborative research projects, based on the six high-priority core issues and two of the medium-priority issues (obesity and sustainable use of natural resources). Proposals are due Nov. 15.

By focusing our limited resources according to these priorities, ANR will continue to deliver the high-quality research and extension programs that Californians need to remain competitive in global markets and maintain their quality of life.

For more information, go to <http://groups.ucanr.org/directions/>



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Plant Sciences

Kevin R. Day

Steven A. Fennimore

News departments

180 Letters

182 Outreach news

California voters assess
anti-GMO initiatives

183 Science briefs

Climate-change study predicts
California water shortage

184 Outreach news (continued)

Nutritionists educate Vietnamese
immigrants about breastfeeding

UC Berkeley's Beahrs program
an oasis for war-weary
global environmentalists

Research articles

186 *Racing for crabs . . .* Costs and management options evaluated in Dungeness crab fishery *Dewees et al.*

Of 12 management options surveyed,
Dungeness crab fishermen preferred one
trap-limit for all vessels and daylight-only
fishing; opinions varied by vessel size.

190 Race for Dungeness crab influences processing, markets *Hackett, Dewees, Krachey*

194 *Conserving California fish . . .* Extension approaches applied to contentious marine-fisheries management issues *Dewees, Sortais, Leet*

Case studies of Sea Grant participation
in implementing a new state marine law,
and in protecting the sea urchin and
Dungeness crab fisheries, reveal impor-
tant lessons for extension involvement.

200 Davis school program supports life-long healthy eating habits in children *Graham et al.*

Lunch participation increased when
salad bars were added in elementary
schools; teachers support garden-linked
nutrition education.

206 Diet, shopping and food- safety skills of food stamp clients improve with nutrition education *Joy*

After 4 to 6 hours of nutrition educa-
tion, low-income food stamp clients were
more likely to eat more fruit and drink
less soda, and to thaw foods properly.



Erik Hill/Getty Images

Dungeness crab is one of the most
valuable Pacific Coast fisheries. While
the fishery is considered sustainable,
about 80% of the crab is harvested
during the first month of the season
(December). This race for crab has
resulted in glutted markets and dan-
gerous competition. The UC Sea Grant
Extension Program surveyed California
crab fisherman about management op-
tions to spread out the harvest more
evenly (see page 186).

209 *Animal Ambassadors . . .* 4-H teens learn to lead science program for kids *Smith et al.*

With training, 4-H teens learned and
implemented innovative, inquiry-based
methods to teach younger children
about science.

213 Low-toxicity baits control ants in citrus orchards and grape vineyards *Tollerup et al.*

Ant pests are often controlled with
broad-spectrum insecticides; in the
field, Argentine and field ants were
attracted to a variety of less-toxic baits.

218 Weeds accurately mapped using DGPS and ground-based vision identification *Downey, Giles, Slaughter*

A video-based weed identification
system linked to a GPS was used to
automatically map nutsedge in a cotton
field; the resulting weed maps were
85% accurate.

222 Information for contributors

Editor's note:
Due to cutbacks related to the state's
budget deficit, *California Agriculture* is
publishing four issues in 2004 instead of six.

Letters

WHAT DO YOU THINK?

The editorial staff of *California Agriculture* welcomes your letters, comments and suggestions. Please write to us at calag@ucop.edu or 1111 Franklin St., 6th fl., Oakland, CA 94607. Include your full name and address. Letters may be edited for space and clarity.

Cattle husbandry extractive by nature

The study, "Long-term grazing study in spring-fed wetlands reveals management tradeoffs" by Allen-Diaz et al. (July-Sept. 2004), supposes that time — 10 years here — restores ecosystems approximately to pristine condition. The stream-water nitrate spike is plainly an artifact of disturbance rather than a "natural" pathology. Were this system allowed full recovery time, there is no doubt the types of vegetation would tend to perennials such as bushes and trees, and that the nitrate released to the water would be the level to optimally fertilize the downstream waters. The article's conclusion makes the unsubstantiated assertion that livestock grazing can be of equal impact to natural grazing (such as deer and antelope in this area). I've lived 10 years in proximity to cattle and know that their "footprint" is not redundant to deer. Fundamentally, cattle husbandry will always be extractive; the "perfect" animal for these ecosystems would be what evolved there.

I was born in California, was a resident for 47 years, and am a UC grad. I continue to have an interest and am grateful for issues of *California Agriculture*.

Stephen Diliberto
Miami, Oklahoma

Lead author Barbara Allen-Diaz responds: In the article, we never state or imply that "time — 10 years here — restores ecosystems approximately to pristine condition." In fact, we make the point that these systems have been focal points for use by wildlife as long as they've been in existence, and for livestock for the last 150+ years. We also never state or imply

that livestock grazing and "natural grazing" are the same. Rather, our goal was to examine and quantify the effects of livestock grazing at particular intensities (including removal) on several spring ecosystem parameters. Our results show that livestock grazing affects different components of the ecosystem differently. And, contrary to popular belief, our data shows that some components, such as nitrate concentrations in spring waters, actually increase with removal of livestock grazing, while biodiversity, for example, is highest with low-intensity grazing. We leave it to readers to render their own opinions about livestock grazing in these systems; we only ask that the readers be informed about the different kinds of responses. We continue to conduct, expand and learn from research in these systems.

Biotech knowledge affects understanding

Congratulations for your leadership in producing the "Fruits of Biotechnology" issue (April-June 2004) and to all of your colleagues who contribut-

ed to this excellent publication. In the early 1980s, the *California Agriculture* publication, "Genetic Engineering of Plants" (Aug. 1982, Vol. 36, No. 8), was acclaimed as a very helpful document for a new field. "Fruits of Biotechnology" is a much-needed step to take this technology to a world desperately in need of it.

It has been difficult to be patient with all of the doubters, especially when their doubts are based on ignorance. Readers of this new publication may still be doubters, but they will now have the knowledge to affect their understanding.

Lowell N. Lewis, Coordinator of Programs
University of California/Catalunya

McGovern reveals ag biotech foes

California agriculture today produces more than twice as much as it did in 1950 on less land. These gains are due to technological advances that have resulted in less hunger and malnutrition due to cheaper and safer food. At the same time, these advances have protected the environment.

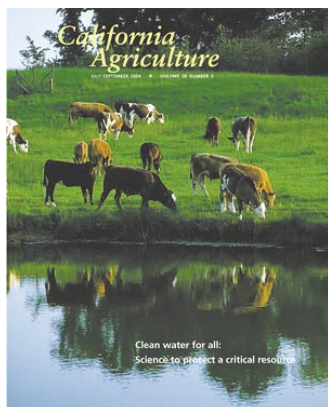
There are those that oppose agricultural biotechnology. George McGovern, one of the most liberal presidential candidates, in his book "The Third Freedom," has the guts to name the opponents of technical agriculture, including genetic engineering. McGovern writes, "I have for years admired the principles and policies of such environmental groups as the Sierra Club and Friends of the Earth...But I believe their opposition to biotechnology as the newly emerging handmaiden of agriculture is both ill-founded and threatening to human survival in the poor countries of the planet."

Groups such as these are costing California agriculture markets today and have reduced the private research effort in agriculture. Without research, in time California agriculture will lose its technological advantage and markets will be lost to countries with lower labor costs. The *California Agriculture* writers (April-June 2004) state there are those that oppose agricultural progress but fail to name them or their bedfellows. Let George do it.

Robert J. Buker
Professor, Ohio State University, Retired
Vancouver, Wash.

Social vs. plant sciences revisited

In his letter (July-Sept. 2004), Professor Thomas Björkman asks: "How does one get biologists to apply their honed skills at unprejudiced analysis to human systems?" and refers to the article by Julian Alston in the previous *California Agriculture* ("Horticultural biotechnology faces significant economic and market barriers," April-June 2004), describing it as "the best teaching tool I have seen for raising the quality of social analysis by bio-



July-September 2004 issue

logical scientists.” Bjorkman contends that Alston approaches “people factors as behaving just as neutrally as plant pathways.”

Undoubtedly there are similarities between life forms as diverse as plants and humans, which may permit plant scientists to believe they work purely in an atmosphere of neutrality. But the difference between plants and humans constitutes an order of magnitude that is staggering. Human beings are reflexive, and have consciousness and “rationality.” Further, human beings can be contrary and contumacious; when they learn about a social science behavior, some deliberately do the opposite. I haven’t heard of any vegetables or fruits having this capacity.

This does not mean that there is no such thing as social science; there is, but we have learned through more than a century and a half of development that there are fundamental differences between the social and natural sciences. We have also learned, through social science investigations, that the natural sciences experience human problems and that, like the social sciences, ostensibly “objective” findings are subject to scientific “negotiation.”

Asking physiologists and horticultural scientists to become social scientists is asking a bit much, although UC had such an opportunity over a decade ago when California Rural Legal Assistance (CRLA) won a suit against UC for conducting research that benefited large-scale industrialized agriculture to the detriment of smaller units of production and farmworkers.

UC fought the suit with great energy and the judge’s ruling was reversed on appeal. But before the reversal, Judge Marsh asked the litigants for a remedy following his ruling. CRLA proposed that UC require its agricultural scientists to prepare “social-impact analyses” of the projected benefits of their research proposals, with technical assistance from a new research and evaluation unit. UC rejected this remedy, even though it would have opened a new and still-developing research area, arguing that the suit and the proposed remedy represented an infringement on the principles of academic freedom. This ignored the system by which non-University funds from private sources or semi-governmental ones (such as marketing orders) leveraged university resources for research in the form of faculty salaries, buildings and equipment.

The Alston article ignored the social costs of genetic manipulation. Likewise, most GM enthusiasts ignore them or express the simplistic hope that the methodology for studying plants has applicability to the infinitely more complex problem of understanding human beings and their social creations.

William H. Friedland
Professor Emeritus
UC Santa Cruz

Correction

Two figures were published incorrectly in “Long-term grazing study in spring-fed wetlands reveals management tradeoffs” (July-Sept. 2004), on page 145 (fig. 3) and page 147 (fig. 5). The corrected figures have been included in the online PDF version, and appear below. *California Agriculture* regrets these errors.

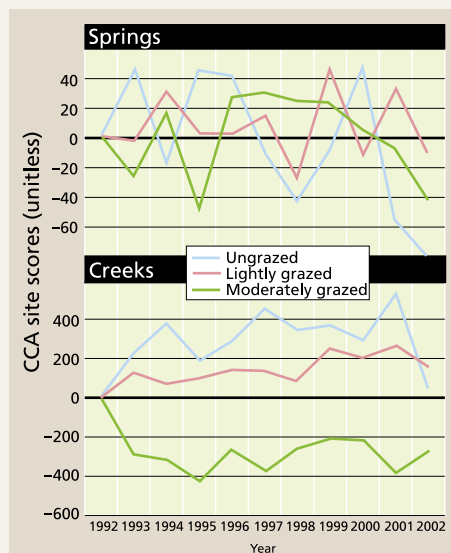


Fig. 3. Species composition over time as affected by grazing intensity in Experiment A.

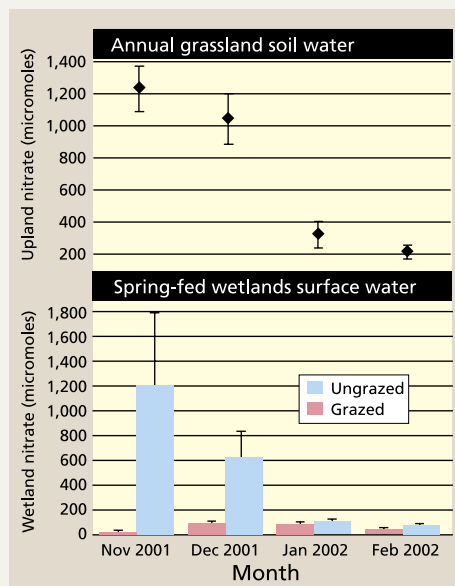


Fig. 5. Soil and surface-water nitrate concentrations from Experiment B during winter 2001-2002.



California voters assess anti-GMO initiatives

The debate over genetically modified organisms (GMOs) is heating up in California. Anti-GMO measures are on the November 2004 ballot in four counties, and even more are in the works for March 2005. In March 2004, Mendocino County became the first county nationwide to pass a ban on the growth and propagation of GMO plants and animals.

This precedent-setting decision by the voters has spawned a rash of similar actions, say two UC scientists who studied the Mendocino campaign. They are Greg Giusti, UC Cooperative Extension (UCCE) forest advisor in Ukiah, and Peggy Lemaux, UCCE biotechnology specialist at UC Berkeley.

The four counties with anti-GMO measures on the November ballot are Butte, Humboldt, Marin and San Luis Obispo; among the counties considering measures for the March 2005 ballot are Alameda, Lake, Napa, Placer, Santa Barbara, Santa Cruz, Solano and Sonoma. "These initiatives could have wide-ranging implications, affecting conventional farming, agricultural and natural resources research, educational institutions and even biotechnology companies," Giusti says. "And county GMO bans could ultimately serve as an impetus for state regulations."

California's anti-GMO movement is being spearheaded by the BioDemocracy Alliance, a consortium of GMO Free Mendocino and the Organic Consumers Association (OCA). The latter worked previously at the state and national levels but now favors county-based efforts. "County campaigns with local activists are more effective than lobbying legislators," says Ryan Zinn, OCA campaign coordinator. However, "we are moving toward statewide legislation that bans or limits the use of GE [genetically engineered] crops," he adds.

Science and local politics don't mix

Mendocino's anti-GMO initiative, Measure H, passed with 56% of the vote, even though no genetically engineered crops are known to grow there. In fact, the issue of GMOs themselves was not even the dominant theme of the Measure H campaign, according to Giusti and Lemaux's analysis of cam-

paign materials, newspaper coverage, editorials and letters to the editor that appeared prior to the vote. "The theme of limiting multinational corporate influence in local agricultural policy and directions dwarfed all others," they say.

After Measure H passed, supporters said it was a "test case for democracy." But Giusti says something important was left out of the Mendocino County GMO debate: science. "Local politics are not driven by accuracy. There's a division between science and local politics, and in Measure H the two sides came crashing together," Giusti says.

Notably, Measure H wrongly defines DNA as a protein, Giusti says, and while state initiatives are checked for accuracy, local initiatives are not. Science was often not considered in the newspapers and debates as locals focused on economic and political themes, Giusti and Lemaux found in their analysis.

Pitting farmer against farmer

The researchers say another problem with local anti-GMO measures is that they can divide communities. The main antagonists in Mendocino County were advocates of organic products (not necessarily agriculturalists) and the biotech industry. But Butte County has farmers on both sides of its anti-GMO initiative, Measure D. Butte is one of the state's major rice-growing counties, and locally Measure D is supported by the largest organic rice grower in the United States, Lundberg Family Farms. However, "there are other farmers who are against it and it's very uncomfortable for the community. It gets personal," Lemaux says.

Measure D is also opposed locally by the Butte County Rice Growers Association and the Farm Bureau, and at the state level by the California Rice Commission, which has the authority to regulate new rice varieties under state law. "They don't want individual counties passing laws that go against existing legislation and dictate the rules applied to rice growing in the state," Lemaux says.

While initiatives are being used to address GMOs in most counties, Lake County is trying

For more information, go to:

UC Statewide Biotechnology Workgroup
<http://ucbiotech.org>

Californians for GE-free Agriculture
www.calgefree.org



another approach. County supervisors asked local organic farmers to work with local conventional farmers, and together to develop a permit process for GMOs. These permits would be considered on a case-by-case basis and would be based on risk assessment. This ordinance-based strategy is in keeping with Lake County's approach to natural resource issues, which emphasizes collaboration, Giusti says. "They're not as quick to try and solve disagreements through political channels. This could serve as a model for other counties to address these conflicts."

In contrast, at the request of proponents only, Trinity County supervisors adopted an anti-GMO ordinance in August, Giusti says. However, the impact will be minimal because 95% of the county is federal land and so is not under the jurisdiction of the ordinance.

Widening implications

Giusti and Lemaux stress the need to work collectively on issues related to GMOs, saying that UC scientists can address people's concerns by providing factual information. "It is not to anyone's advantage to be divided into camps of us versus them," Giusti says. "This is too important and too complex. UC researchers can help by explaining the science that relates to the risks and benefits of GMOs."

The importance of informed debate is growing as the scope and number of anti-GMO initiatives increases. For example, the Butte County anti-GMO measure would keep the California Rice Experimental Station from performing any genetic-engineering experiments on-site. Moreover, the Butte County initiative goes further than Mendocino County's and stipulates exactly what can and can't be grown in the county. Having an "allowed" crop list could be a problem for local rice growers, Lemaux says, because it does not specifically include rice with mutations induced by X-rays or gamma radiation. It means legally these varieties could be banned too, Lemaux says. Much of the rice grown in Butte County fits into this category.

UC researchers can help avoid such problems by checking the wording of initiatives. "We shouldn't be involved in the politics, but people should use us as a sounding board and clearinghouse for accurate information," Giusti says.

In addition, some of the initiatives on the November 2004 ballot ban all GMOs, not just crops and animals. This means they also apply to micro-

organisms and so could affect biotech companies in some counties, like Alameda, Lemaux says.

The county anti-GMO initiatives could also have statewide impact. "If enough of them pass, that could force state legislation," Lemaux says, noting that county pesticide regulations drove the development of statewide regulations. Currently, the state does not regulate GMOs; field-test applications are overseen by the U.S. Department of Agriculture. Alternatively, anti-GMO successes at the county level could help supporters place an initiative on the state ballot.

"Whatever happens in November could change the complexion of agriculture in California," Lemaux says.

— Robin Meadows

▲ Grassroots campaigns against genetically engineered crops have spread to numerous California counties, with four initiatives on the ballot in November 2004 and others in the works for the March 2005 ballot.

Science briefs

Climate-change study predicts California water shortage

California will experience significantly hotter summers by 2100, with resulting impacts on human health and the availability of water that could upend the state's current water rights system, according to a study by team of 19 scientists.

"These new predictions illustrate more than ever the urgent need to control greenhouse gas emissions now," says study co-author W. Michael Hanemann, professor of agricultural and resource economics and director of the California Climate Change Center at UC Berkeley. "Because of lags in the natural system, what we do today will affect climate 30 years from now."

The findings were published in the August *Proceedings of the National Academy of Sciences*; the lead author is Katharine Hayhoe of ATMOS Research and Consulting. Using the most sensitive climate models to date, the researchers studied two scenarios: one assumes a business-as-usual approach to the use of fossil fuels, while the other factors in lower emissions when switching to alternative energy and more fuel-efficient technology. Under the lower emissions scenario, summer temperatures in California would rise 4°F to 5°F by the end of the century; if nothing is done to curb the use of fossil fuel, summer temperatures would rise a dramatic 7.5°F to 15°F. Those figures are several degrees higher than previous models had predicted, particularly in the summer months.

Statewide, the length of the heat-wave season could be dramatically extended from an average of 115 days per year to 178 to 204 days by 2100, while the Sierra snowpack could decline by as much as 90% if fossil fuel use isn't curbed, the study finds.

"Increases in temperature decrease water availability while increasing demand," Hanemann says. "It will no longer just be a battle among the farming industry, the environmental groups and the cities, but those within each interest group will be competing with each other for water."

Nutritionists educate Vietnamese immigrants about breastfeeding



Far left, Hien Truong, a San Jose obstetrician, shares breastfeeding information with a pregnant patient. Left, UC Cooperative Extension developed six brochures targeted to reach Vietnamese immigrants, whose breastfeeding rates are among the lowest of California ethnic groups.

Although breastfeeding is healthier for babies and mothers, Southeast Asian women who immigrate to the West are far more likely to bottle-feed due to language and cultural barriers.

"They almost never see anyone breastfeeding," says Joanne Ikeda, UC Cooperative Extension (UCCE) nutrition specialist, who developed an intervention to promote breastfeeding among Vietnamese immigrants. "Most U.S. women seek privacy for breastfeeding, unlike other cultures where it is done more openly in public."

To help overcome barriers to breastfeeding, Ikeda and Kim-Phuc Nguyen, UCCE research nutritionist, adopted a three-pronged approach: they developed educational materials tailored to Vietnamese women; provided in-service training to physicians on the importance of breastfeeding; and distributed these materials for doctors to use with their pregnant patients. Giao Pham, a physician provider liaison with Blue Cross of California, was a consultant to the project.

Since doctors are held in high esteem in Vietnamese-American communities, they have a lot of influence with their patients. "They can help increase the low rates of breastfeeding by advising mothers to do so," Nguyen says.

The American Academy of Pediatrics recommends breastfeeding babies for a year, in part because breast milk contains antibodies that help protect infants from ear and respiratory diseases, as well as gastrointestinal infections. Breastfeeding also benefits mothers by, for example, reducing the risks of osteoporosis, and breast and ovarian cancers.

While Southeast Asians typically breastfeed in their native countries, this ethnic group has the lowest breastfeeding rate in California. Between 1997 and 1999 only 20% of the state's Vietnamese mothers breastfed their newborns at the hospital, compared with 62% of white mothers, according to a California Department of Health Services report. "There is no

choice in Vietnam but here they say 'Why breastfeed? Everything is all ready,'" Nguyen says.

Many Southeast Asian immigrants also believe that formula is superior to breast milk, because their breastfed Asia-born infants were more likely to die than their U.S.-born, bottle-fed infants. Other factors in the decision to bottle-feed include the fear of not making enough milk and the pressures of going back to work, Nguyen says.

Prenatal education evaluated

Prenatal education and support are the best ways to increase breastfeeding rates, Ikeda says. To help educate Vietnamese immigrants, UCCE collaborated with the Vietnam Physician's Association of Northern California to develop six breastfeeding pamphlets in their native language. The pamphlets explain the health benefits, dispel myths and offer advice on overcoming problems.

Equally important, "the educational materials are culturally appropriate," Nguyen says. For example, because many Southeast Asians are lactose-intolerant, the materials advise nursing mothers to eat calcium-rich foods such as sardines and tofu rather than milk and cheese.

As a component of a pilot program to evaluate the effectiveness of this approach, in 1999 the educational materials were distributed to 11 Vietnamese physicians, who in turn gave them to Vietnamese women during prenatal examinations. In an unpublished survey of 78 mothers who received the educational materials, the researchers found that the breastfeeding rate was initially high but then dropped off sharply. While more than 90% of the mothers breastfed in the hospital, the rate fell to 60% at 4 weeks, about 20% at 4 months and 15% at 6 months. The results suggest that mothers need more education and support after leaving the hospital, Nguyen says.

The materials are available online and are being used by health organizations around the country, including Kaiser in Oakland and the U.S. Department of Agriculture's Women, Infants and Children (WIC) program.

The pilot program "sought to demonstrate that convincing physicians of the importance of breastfeeding, and having them promote this practice with their patients, can increase breastfeeding rates among Southeast Asian women in California," Ikeda says.

— Robin Meadows

For more information, go to:
www.nal.usda.gov/wicworks/Sharing_Center/statedev_vnbreastfeeding.html
 and
<http://nutrition.berkeley.edu/extension/vietnamese.html>

UC Berkeley's Beahrs program an oasis for war-weary global environmentalists

A striking number of international participants in a UC Berkeley environmental management course face daunting challenges to promote sustainable development in their countries — particularly in wake of war, military conflicts and their aftermath.

They were among 35 environmental professionals in the 4th annual Beahrs Environmental Leadership Program (ELP) in Sustainable Environmental management held this summer.

"Our country is in a mess," explains Dinesh Paudel, forestry development coordinator for the Nepal Swiss Community Forestry Project in Kathmandu, Nepal. With 70% of the Nepalese countryside under the control of Maoist guerillas, tourism has collapsed and the small country's once-hopeful community forestry initiatives are threatened. "The mismanagement of environmental resources has become a root cause for the conflict," Paudel says.

Paudel and colleagues from 19 countries were convened by the Center for Sustainable Resource Development in UC Berkeley's College of Natural Resources. Together with an interdisciplinary team of UC Berkeley faculty, researchers and local community activists, they tackled complex issues from urban environmental justice to sustainable livelihoods. The intensive 3-week ELP summer course offers midcareer professionals, mainly from developing countries, a full schedule of workshops, lectures and field trips, including training on conflict management and strengthening leadership skills.

"It takes a few days for participants to shed their anxieties and work-related stress, but eventually they let down their guards, stimulate their minds and creativity, and make friends across borders, religions and disciplines," says Robin Marsh, ELP co-director. "It's an empowering experience."

As an ELP alumnus, Paudel plans to submit a proposal to the ELP Small Grant Initiative, in collaboration with the Haas School of Business at UC Berkeley. "I want to get their advice and help to set up a business model in which valuable forest products are used sustainably and marketed effectively," he says, "so people can get real money, not peanuts."

Likewise, ELP participant Sayed Hashmat, a top Afghani irrigation engineer, says that years of mismanagement, neglect and outright destruction by the Taliban (and previously the Mujahideen) have left Afghanistan's agricultural irrigation systems in a shambles. Hashmat discussed irrigation and the environmental impacts of dam construction with UC Berkeley entomology professor Vincent Resh and his doctoral students during a full-day ELP workshop



Participants in the 2004 Beahrs Environmental Leadership Program included, left to right, UC Berkeley entomologist Vincent Resh and Sayed Hashmat, an Afghani irrigation engineer; Dinesh Paudel, Nepalese community forestry coordinator; and Aventino Kasangaki, Ugandan wildlife ecologist, and Anyaa Vohiri, Liberian environmental lawyer.

at the UC Botanical Garden. "I hope we can return to peace. If we have security, we can have all kinds of restoration projects," Hashmat says.

Established in 2000 with funding from UC Berkeley alumni Richard and Carolyn Beahrs, the program strives to foster ongoing networks and knowledge exchanges. The course has launched numerous projects between UC Berkeley, Bay Area environmental leaders and ELP alumni, including in South Africa, Cameroon, Indonesia, Russia, Mexico and Vietnam.

Resh has taught in the program since its inception and traveled to the Republic of Georgia this year to provide technical assistance on water-quality monitoring, in collaboration with an ELP graduate. "It's amazing how the [ELP participants] work under these unbelievable conditions and are still getting meaningful work done," Resh says.

The connections that participants make may be most valuable to them in the long run, Resh adds. "I think they benefit from the program less from us than from each other."

ELP participant Anyaa Vohiri, for example, works for Fauna and Flora International as manager of their Liberia Forest Re-assessment Project. A native Liberian, Vohiri was educated and spent most of her adult life in the United States. "Logging was used to fuel 14 years of civil war in Liberia," says Vohiri. Her efforts to preserve and restore Liberian forests focus on creating nature preserves and implementing sustainable management of forest resources.

The ELP has "given me an integrated look at what is affecting the environment," Vohiri says. "It has given me the tools to ask questions. And if I run into a problem, I'm able to call these 34 people as well as the scientists at Berkeley." — Janet Byron

For more information,
go to:
<http://nature.berkeley.edu/BeahrsELP>

Racing for crabs . . .

Costs and management options evaluated in Dungeness crab fishery

Christopher M. Dewees
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Dungeness crab support a valuable commercial fishery in California, yet in recent decades the fishery has intensified significantly, with most crab landed during the first 6 weeks of the 7-month season. This study of fishermen's operating costs and their opinions of new management measures is intended to support discussions and decision-making about policy changes that may affect the economics of the fishery. Our survey results show that a majority of fishermen have favorable views of only two of 12 alternative measures (one trap-limit for all size vessels and daylight-only fishing). However, opinions of these measures vary between owners of different-sized vessels. Experiences in other crustacean trap fisheries around the world suggest that simply implementing these two measures may not significantly decrease total trap numbers fished or slow the race for crab.

Dungeness crab range from Santa Barbara to Alaska's Aleutian Islands. Commercial landings fluctuate widely each winter, but consistently rank as one of the most valuable Pacific Coast fisheries. From the 1990-1991 season (generally December through June) through the 2000-2001 season, combined landings for California, Oregon and Washington averaged 32.8 million pounds, worth between \$31.7 million to \$84.4 million annually to fishermen (Didier 2002).

California's Dungeness crab (*Cancer magister*) fishery began in the San Francisco area about 1848 and expanded



The Pacific Coast's commercial Dungeness crab fishery pulls in between \$32 million and \$84 million annually, with crab abundance peaking in approximately 10-year cycles. While the catch has been sustainable, in recent years 80% of landings have been made in the first full month of the season (December). Crab boats are loaded with traps in Crescent City, Calif., before the season opens.

northward after World War II. The fishery has long been intense and highly competitive. On Dec. 11, 1949, a *Humboldt Times* headline reported, "Three Crescent City fishermen beaten in San Francisco crab war . . . Bay Area men ired at northern poachers."

California landings have been highly variable, ranging from a low of 350,000 pounds in 1973-1974 to more than 30 million pounds in 1977-1978 (Hankin and Warner 2001). A small but growing recreational fishery is believed to take less than 1% of the harvest. Peaks in abundance appear to occur in approximately 10-year cycles.

The fishery has been fully and intensely exploited for at least 40 years. Approximately 80% to 90% of the legal-sized male crabs are harvested each season. Despite this intense harvest and high variability in abundance, most scientists and industry participants feel that current regulations are adequately protecting the crab resource (Hankin and Warner 2001). These regulations

include a 1995 cap on the number of vessels allowed to harvest Dungeness crab in California waters, a 6.25-inch minimum harvest size for male crabs, approximately 5 months annual closure to harvesting, no take of female crabs, and mandated escape openings on traps for undersize crabs. California's seafood industry has appreciated what appears to be a sustainable and valuable harvest of Dungeness crabs at a time when other major fisheries such as rockfish and salmon have declined significantly.

Yet juxtaposing the sustainability of crab stocks is the fishermen's intensifying yearly race for crab. In recent decades, the increasing number of vessels and intensity of their participation has led to a race for crabs. Though landings have come primarily during winter months since at least 1950, before 1980 the crab season was spread from December to July. In recent years, approximately 80% of the landings are made in December (Hankin and Warner

The fishermen's intense race has led to glutted markets, increased densities of crab traps on the fishing grounds, and fishing in dangerous conditions leading to loss of lives and vessels.

2001). The fishermen's intense race has led to glutted markets, increased densities of crab traps on the fishing grounds, and fishing in dangerous conditions leading to loss of lives and vessels.

In 1995, the crab industry and the California Department of Fish and Game (DFG) began to address the harvesting over-capacity with legislation mandating a moratorium on the issuing of more permits for vessels to harvest Dungeness crab. While this restricted the number of vessels to about 600, it did nothing to limit the amount of fishing effort (time, traps, vessel size, horsepower) used by these participants. Reduced opportunities in other fisheries, especially those targeting rockfish and other groundfish, have increased fishing effort directed at crab.

For years, fishermen have discussed spreading harvests more evenly through the season, but have come to no agreements. To contribute to this discussion, we surveyed California Dungeness crab fishermen to gather basic demographic and economic data and to measure their opinions on current and potential fishery management measures. Our research is intended to provide an information base from which industry may decide what next steps (if any) they wish to take.

Survey of crab fishermen

Our first step was to review regulatory management tools used in other crustacean trap fisheries around the world via a literature review and contacts with fishery managers (see box). Most of these management tools address issues related to over-capacity in fishing fleets and slowing the pace of harvest. We provided this information to fishermen with our mail survey questionnaire.

Our primary research tool was a six-page mail survey sent to the 616 individuals who purchased California commercial Dungeness crab vessel per-

mits for 2001. We designed our survey based on Dillman (2000). We asked permit holders about characteristics of their fishing business, crab fishing costs, revenues and effort, their opinions of the current management system and their opinions of 12 potential management tools (contact first author for a copy of the questionnaire). We asked fishermen to rank their responses to each management tool on a five-point Likert scale (strongly unfavorable to strongly favorable). The survey concluded by giving respondents an opportunity to describe their vision of the best system for managing California's Dungeness crab fishery.

Given widespread wariness among fishermen that research might lead to new regulations that would hurt their operations, we actively conducted pre-survey outreach. We met with focus groups of 2 to 25 crab fishermen at four major ports (Crescent City, Eureka, Noyo and Bodega Bay) and at a California Salmon Council meeting in Sacramento. At these meetings we distributed summaries of crustacean management tools in use internationally, attempted to assuage fears about participation in the project, answered questions, asked for advice on increasing response rates, and pre-tested and received feedback on draft surveys.

After multiple revisions and two pre-tests, we mailed our final survey in November 2002. We sent only one survey to the 27 fishermen we could identify as owning multiple California crab permits. Two weeks after mailing the surveys, we sent a follow-up postcard to all permit holders as a reminder and offered a replacement survey if necessary.

Seven surveys were returned as undeliverable and 243 were returned completed, a response rate of 40%. We believe our sample is generally representative of the total crab fleet. Survey respondents generally reflect the home-port distribution of all permit holders (table 1).

Regulatory management tools

Daylight-only fishing: Harvest is permitted during daylight hours only.

Individual fishing quotas (IFQ): Allocates a portion of the total allowable catch (TAC) to individual vessels based on agreed-upon criteria such as catch history or vessel characteristics. IFQs can include: (1) **individual transferable fishing quotas**, which can be sold or leased (either freely or within agreed-upon constraints) among fishery participants; (2) **individual fishing quotas**, which are not transferable; (3) **community quotas**, in which part or all of the total allowable catch is allocated to a community or group of associated individuals to allocate locally among fishery participants.

One trap-haul (pull) per day: Hauling gear to the surface is permitted once per day.

Regional/area/zonal management: Management differs between locations (for example, seasons, trap limits and total allowable catches differ by locale).

Trap certificates: Allow individual fishermen to use a certain number of traps for the season. Each certificate represents one trap. Trap certificates can be: (1) **transferable**, in which a portion of an overall trap total is allocated to fishermen and can be sold or leased in or out (either freely or within agreed-upon constraints); or (2) **nontransferable**, allowing fishermen to choose a tier within a per-vessel maximum trap limit.

Trap limits: Establishes the maximum number of traps a vessel can fish. They can be: (1) **one maximum**, which applies to all vessels regardless of vessel size; (2) **multi-tier**, with several different maximum limits for different-size vessels or other criteria; (3) **graduated**, which change over the season (for example, increasing as crab abundance declines or as the season goes on).

Trip limits: Limits the landings that individual vessels can make per trip.

TABLE 1. Home-port distribution of vessels with California Dungeness crab vessel permits compared with home-port distribution of survey respondents

City	Respondents	Permitted vessels
	% (n)	%
Crescent City	19.5 (46)	20.0
Trinidad	4.8 (11)	3.9
Eureka	14.0 (33)	11.6
Fort Bragg	13.1 (31)	8.8
Bodega Bay	12.3 (29)	11.3
San Francisco	6.8 (16)	13.6
Half Moon Bay	11.4 (27)	8.9
Santa Cruz	1.7 (4)	2.1
Moss Landing	0.4 (1)	1.8
Morro Bay	1.7 (4)	1.1
Avila Beach	1.8 (3)	1.3
Other CA ports	4.8 (11)	6.1
Oregon ports	8.7 (20)	9.6

Source: California Department of Fish and Game license data (April 2003).

TABLE 2. Characteristics of individuals with California Dungeness crab vessel permits (number of respondents)

	n
Length of primary crab fishing vessel	
Small: < 30 feet	35
Medium: 30–50 feet	137
Large: > 50 feet	63
Tenure in fishery	
0 to ≤ 9 years	42
> 9 to ≤ 19 years	61
> 19 to ≤ 29 years	77
> 29 years	56
% of gross income from Dungeness crab fishing, 2002	
≤ 20%	17
> 20% to ≤ 40%	46
> 40% to ≤ 60%	66
> 60% to ≤ 80%	83
> 80% to 100%	23
Mean number of days fishing Dungeness crab, 1998–2000	
≤ 50 days	32
> 50 to ≤ 100 days	53
> 100 to ≤ 150 days	62
> 150 to ≤ 200 days	50
> 200 days	19
Mean number of traps fished, 1998–2000	
≤ 200 traps	67
> 200 to ≤ 400 traps	96
> 400 to ≤ 600 traps	40
> 600 traps	21

Fleet characteristics, costs

When compared to DFG permit data, our sample contained a similar proportion of owners of vessels under 30 feet (14.9% versus 15.4%). Medium vessels are slightly under-represented (58.6% versus 70.8%), and vessels over 50 feet (which tend to be the largest producers) are over-represented (26.8% versus 13.8%)(table 2). The majority of survey respondents own medium vessels and about half have at least 20 years of experience fishing crab. About 75% fish with fewer than 400 traps.

Trap deployment. By looking more closely at trap usage, we found that during the 2000–2001 season fishermen deployed an average of 293 traps per vessel during the peak fishing month of December. On average during December, small, medium and large vessels fished 138, 259 and 448 traps each, respectively. Trap numbers increased substantially with vessel size, reflecting increasing capability to carry traps. During the first month or two of the season traps were usually hauled daily. As crab density and catch rates declined, traps were often pulled at 48- to 72-hour intervals. Fishermen will move their traps to different areas or depths in search of improved catch rates.

By extrapolating the mean number of traps by vessel size fished by respondents, to the total number of permit owners by vessel size, we estimate that 171,090 traps were deployed in California's crab fishery in December 2000. This compares with estimates of 146,978 and 64,806 traps in Oregon and Washington during the same time period (Didier 2002). While we are not aware of any other estimates of California trap numbers since the 1975–1976 season, Didier estimated that from 1971–1972 through 1975–1976 California trap numbers averaged 29,115. During the same

period Oregon and Washington trap estimates were 52,380 and 35,840, respectively. It seems clear that the amount of fishing gear in California waters has increased significantly since 1975–1976.

Other fisheries. Dungeness crab fishing is just one of several fisheries that fishermen utilize during the year. Salmon, albacore tuna, groundfish, pink shrimp, sea urchin and live fish were often mentioned in the diverse mix of target species. We were surprised at the relative importance of crab to respondents; 73% indicated that more than 40% of their gross income came from fishing Dungeness crab (table 2). For those with vessels less than 30 feet, crab fishing appears to be a relatively minor component of their incomes.

Value of permits. When we asked fishermen to estimate the value of their crab permit, estimates increased with vessel size. On average, owners of small, medium and large vessels estimated their permit value at \$10,303, \$18,187 and \$31,111, respectively (roughly \$500 per foot of vessel length). Larger vessels are able to load, move and fish more traps. They can also better handle the dangerous winter weather conditions and are more likely to be able to fish day and night. In addition, some of the larger vessels can hold large quantities of crab in live wells onboard, enabling them to take multiday trips.

Fishing costs. As average trap usage increases by vessel size, so do annual and daily variable costs attributed to crab fishing (table 3). Gear repair primarily involves replacement of lost or worn-out traps, while trap storage costs occur in the off-season. Crewmembers are typically paid a percentage of the landings proceeds, reflecting traditions of crew motivation and sharing risk. Crew costs increase with vessel size because larger vessels often require two deckhands to handle the larger number

TABLE 3. Mean Dungeness crab fishing costs of survey respondents, by vessel size

Vessel size	Annual costs		Daily costs		Other	
	Gear repair	Trap storage	Bait	Fuel	Variable costs	Crew share
	\$ (SD*)					%
Small: < 30 feet	2,239 (1,932)	149 (228)	57 (63)	41 (44)	40 (54)	15 (10)
Medium: 30–50 feet	4,006 (3,259)	626 (936)	155 (233)	68 (137)	41 (52)	24 (11)
Large: > 50 feet	6,656 (4,072)	1,650 (2,237)	226 (163)	150 (83)	62 (29)	31 (10)

* Standard deviation.

TABLE 4. Opinions of Dungeness crab survey respondents on proposed management tools

Management tools (n)	Strongly fav.* or fav.	Neutral	Strongly unfav. or unfav.	Mean score (SD)†
Current management system (198)	153	19	26	4.11 (1.18)
One trap-limit for all size vessels (196)	138	9	49	3.85 (1.63)
Daylight-only fishing (222)	143	15	64	3.59 (1.67)
Transferable trap certificates (188)	72	17	99	2.68 (1.74)
Nontransferable trap certificates (168)	61	16	91	2.67 (1.72)
Trip limits (186)	67	17	102	2.60 (1.67)
Different trap limits for different-size vessels (187)	72	9	106	2.60 (1.66)
One trap-haul per day (211)	62	36	113	2.59 (1.60)
Regional/area/zonal management (206)	69	23	114	2.54 (1.64)
Transferable IFQs‡ (197)	45	16	136	2.08 (1.34)
Nontransferable IFQs (190)	26	15	149	1.80 (1.53)
Community quotas (205)	20	14	171	1.62 (1.14)
Graduated trap limits (148)	9	23	116	1.61 (0.98)

* Favorable.

† Scale: 1 = strongly unfavorable, 2 = unfavorable, 3 = neutral, 4 = favorable, 5 = strongly favorable. (Standard deviation.)

‡ Individual fishing quotas.

of traps hauled each day, whereas small vessels usually have just one deckhand in addition to the skipper.

Views on management tools

The heart of our research was our analysis of fishermen's opinions of management tools. Opinions generally fell into three tiers (table 4). The majority of respondents expressed a favorable or strongly favorable opinion of only three tools: the current management system, one trap-limit for all size vessels and daylight-only fishing. The current management system consists primarily of regulations designed to sustain crab populations, whereas the 12 other management tools relate to vessel operations, economics and allocation of the catch.

The large majority of respondents approved of one trap-limit for all vessels rather than having trap limits based on vessel size. There was little support for limiting overall statewide trap numbers by issuing transferable or nontransferable trap certificates to individual vessels. Fishermen expressed almost no support for increasing trap limits during the season as crab densities on the fishing grounds decline.

A majority of respondents also supported confining fishing to daylight hours. This measure would limit the number of traps that could be pulled on a single day. Currently some vessels, primarily larger ones, operate 24 hours a day and are able to fish more traps. Allowing only one pull of traps per day

received little support. Respondents expressed concerns about the ability to enforce this regulation short of onboard video cameras.

The use of harvest-rights systems such as individual or community quotas, which have been used elsewhere to slow the race for fish and shellfish, garnered little support. Respondents mentioned concerns about aggregation of harvest rights in the hands of a few and DFG's lack of ability to determine annual quotas as barriers to implementation of these types of quota systems.

Finally, only a minority favored managing the fishery with differing regulations in different zones, even though there are currently different season opening and closing dates in Northern and central California.

Vessel size & management opinions

In discussions at our five pre-survey focus-group meetings and with fishery managers, we found that much of the historical and current disagreement over alternative management approaches has been among participants with different-sized vessels. Industry discussions about trap limits and zonal management have broken down over differences between owners of large as compared to medium and small vessels. For this reason we decided to take a closer look at the differences in opinions of management tools based on vessel size categories (vessel size is also highly correlated with number of traps

used, percentage income from crab fishing and number of days fishing for crab annually). Vessels were divided into three length categories: less than 30 feet (small), 30 to 50 feet (medium) and larger than 50 feet (large). These categories are the same as those used by the Pacific States Marine Fisheries Commission in their analyses of California, Oregon and Washington Dungeness crab fisheries (PSMFC 1993).

We tested the null hypothesis that opinions regarding the 13 management tools do not differ among vessel size categories (small, medium and large). We first used a Kruskal-Wallis test (Hays 1988) to determine if there were significant differences in opinions. When the Kruskal-Wallis test indicated significant differences among categories, we then used the Kolmogorov-Smirnov test to make specific pair-wise comparisons across vessel size categories. To test whether difference exists in the mean response across two categories, a randomization test based on Manly (1997) and written by the authors was used. We report the mean *P* value of the 10,000 simulations here.

Using the Kruskal-Wallis test, we rejected the null hypothesis that respondent opinions are the same across the vessel size categories for five alternative management tools (table 5). Generally, as vessel size increases, support decreases for one trap-limit for all size vessels, trip limits, community quotas, regional management and daylight-only fishing. When we tested for pair-wise differences between specific size categories, large vessel owners' opinions were significantly different from both medium and small vessel owners on all five management tools. Differences between small and medium vessel owners' opinions differed only on regional management.

Implications for the fishery

Though the pace of Dungeness crab fishing has continued to intensify, it remains a profitable and important fishery. Crab processors have evolved strategies to deal with the huge early-season pulse of crab landings (see sidebar, page 190). At the same time, fishermen continue to struggle to find ways to cope rationally with the increasing intensity of the crab harvest.

Race for Dungeness crab influences processing, markets

Steven C. Hackett
Christopher M. Dewees
Matthew J. Krachey

IN recent decades the California Dungeness crab fishery has experienced a race for crabs, or derby, where approximately 80% to 90% of annual seasonal landings occur between late November and the end of December. Some processors have responded by developing large-scale processing and freezing capacity that can accommodate the pulse of crab landings and be used for processing other fish species at other times of the year. The combination of large-scale processing and declines in the groundfish and salmon fisheries has resulted in a more consolidated processing industry structure that features a small number of large processing firms.

Baseline economic information was collected on this processing sector in California for two Dungeness crab fishing seasons, 1999-2000 and 2000-2001 (Hackett et al. 2003). Our research methodology involved the use of confidential fish-ticket data from the California Department of Fish and Game, and interviews with key informants at six processing firms. These firms, located in California and southern Oregon, purchased 60% of the crab landed in California in 1999-2000. We found that:

- The estimated average wholesale price of various Dungeness crab products (adjusted for yield rates from the live crab) in 1999-2000 was approximately \$3 per pound.
- The estimated value added by processors ranged from \$8.45 million to \$8.83 million. Value added by processors is measured as processed-crab sales revenue less the cost of crab purchased from fishermen, whereas value added by fishermen is measured as revenue received by fishermen for selling crab to processors.
- The estimated value added by processors ranged from 47.5% to nearly 50% of that added by crab fishermen.
- The value added by fresh and live products (based on yield-adjusted prices expressed as a percentage of the ex-vessel value) was generally less than that of the frozen and picked-meat products.



About half of the Dungeness crab catch is sold fresh or live, while the rest is frozen or processed into picked meat. This crab has two red tags; cooperating commercial fishermen return the tags so that researchers can estimate crab movements and collect other data.

Prices. If fresh and live product are perceived by consumers as possessing superior quality to that of the frozen product (much of the picked meat originates from the secondary processing of previously frozen crab), then presumably this would be manifested in higher prices per pound for the fresh and live product, especially if the pulse of landings suppresses this product. In fact, our analysis suggests that this was not the case — the frozen and picked meat featured higher yield-adjusted prices per pound than those of fresh and live product. Our estimates indicate that only about one-half of the Dungeness crab landed in California was processed into fresh or live product during the 1999-2000 and 2000-2001 seasons.

Value of picked meat. The superior yield-adjusted price for picked-meat product could be explained by the notion that many final consumers (such as diners at restaurants and on cruise ships) value convenience over freshness, since picking meat from a Dungeness crab is a somewhat laborious task. In fact, our estimates for percentage value added in 1999-2000 are consistent with the picked-meat product having the highest yield-adjusted value in the marketplace (though this was somewhat less evident in the 2000-2001 estimates). Processors in our interviews noted the importance of maintaining restaurant, cruise ship and other food-service accounts that

serve as key market channels for picked meat. The importance of maintaining these picked-meat market channels is indicated by trends in the estimated share of total statewide Dungeness crab landings going into the picked-meat product. The percentage of crab processed into a picked-meat product generally increased in 2001, when landings had decreased, indicating the importance of protecting market channels for picked meat.

Employment. Hackett et al. (2003) were only able to get sufficient information on employment and capital stock in Dungeness crab processing from surveys to develop industry-wide estimates for the 2000-2001 season. Estimated total peak crab-processing employment in 2000-2001 ranged between 485 and 552 people during the weeks when the pulse of Dungeness crab landings is being processed. In contrast, off-peak “year-round” industry-wide employment (mostly picking lines) was estimated to range between 88 and 142 people.

Luxury/special occasion food. Most of the processors surveyed consider Dungeness crab to be a seasonal or a luxury food associated with celebratory events, with peak consumption of fresh crab occurring between Thanksgiving and New Years Day. Processors noted difficulty in moving fresh crab after late January (Super Bowl weekend). Because fresh or live crab is difficult for consumers to locate after late January, it is impossible to judge whether consumer demand would increase if it were available for longer.

There is certainly substantial demand for the live product during the holiday season when it is available.

Frozen product. The large processors mentioned that target inventory levels for frozen crab are usually set prior to the season based on existing inventory and projected consumer demand. Processors base their demand estimates on overall economic indicators (economic growth, consumer confidence) and the price and availability of substitutes. Key substitutes were reported to be Dungeness crab products out of Washington, Oregon and British Columbia; snow crab products; and more generally, other seafood and meat products. As the season begins and it becomes clear that target inventory levels will be reached, production shifts to include fresh and live product. Processors noted that fresh product is easier to unload quickly. In years with low landings, large processors focus most of their production on frozen products, leaving more of the fresh and live market to smaller processors.

New markets. The processors interviewed reported considerable difficulty in moving large quantities of fresh crab product outside of the region due to the cyclical nature of the fishery. In years with large landings, the industry is able to develop new markets, such as East Coast restaurants. These processors report high product satisfaction in these new markets. But when years with small landings come along, processors report that rising ex-vessel prices put upward pressure on fresh product prices, and out-of-region markets are more price-sensitive than those within the region due to reduced product identity. Processors claim that this price sensitivity effectively eliminates fresh Dungeness crab products from being regular restaurant menu items outside of the region.

David G. Hankin and Kristen Sortais contributed helpful review of this sidebar.

Reference

Hackett SC, Krachey MJ, Dewees CM, et al. 2003. An economic overview of Dungeness crab (*Cancer magister*) processing in California. CalCOFI Report 44:86-93.

TABLE 5. Opinions* of survey respondents on crab management tools, by vessel size category

Management tools	Vessel size		
	Small < 30 ft.	Medium 30 to 50 ft.	Large > 50 ft.
Current management system	4.3	4.1	3.9
One trap-limit for all size vessels†	4.1§	4.3§	2.8
Daylight-only fishing†	4.5§	3.8§	2.6
Transferable trap certificates	2.8	2.6	2.6
Nontransferable trap certificates	2.3	2.9	2.5
Trip limits‡	3.1	2.7§	2.1
Different trap limits for different-size vessels	3.1	2.3	3.0
One trap-haul per day	2.9	2.7	2.2
Regional/area/zonal management†	3.3§#	2.7§	1.7
Transferable IFQs**	1.9	2.0	2.3
Nontransferable IFQs	2.2	1.7	1.7
Community quotas‡	2.2§	1.7§	1.1
Graduated trap limits	1.8	1.7	1.3

* Scale: 5 = strongly favorable, 4 = favorable, 3 = neutral, 2 = unfavorable, 1 = strongly unfavorable.

† Vessel size categories significant, Kruskal-Wallis test, $P = 0.01$.

‡ Vessel size categories significant, Kruskal-Wallis test, $P = 0.05$.

§ Significantly different from large vessels, Kolmogorov-Smirnov test, $P = 0.01$.

¶ Significantly different from large vessels, Kolmogorov-Smirnov test, $P = 0.05$.

Significantly different from medium vessels, Kolmogorov-Smirnov test, $P = 0.05$.

** Individual fishing quotas.

There is widespread approval among fishermen of the current crab-management regulations based on traditional fishery management tools with seasons. However, when additional regulations are considered that affect fishing operations, opinions become highly polarized or negative.

Trap limits. The great increase in the number of traps fished and the accelerating pace of the fishery has led to years of discussion about whether to limit the number of traps each vessel may fish. On Sept. 23, Governor Schwarzenegger vetoed a bill that would have established a limit of 250 traps per vessel south of Point Arena, on an experimental basis. Our study showed that the majority of the fleet, with the exception of the large vessel owners, viewed trap limits favorably. Many of those survey respondents who oppose trap limits stated that they viewed it as a reallocation of crab to smaller operators. They saw this as a restriction of their business that was unjustified in terms of resource conservation.

We anticipate that trap limits would at best cap the total number of traps near current levels and prevent large increases in fishing effort. After implementation of trap limits in Maine's lobster fishery, the total number of traps fished increased (Acheson 2001). While the relatively few lobstermen above the trap limit reduced their operations, many of those under the limit increased their trap numbers toward the limit. Depending on the level set for trap limits,

California's outcome could be similar. One alternative approach would be to scale trap limits to vessel length. However, the fleet did not rank this option favorably (table 4). California should also examine the early outcomes from trap-limit systems recently implemented in Washington state. Inside Puget Sound, trap limits are set at 100 per vessel and there are six harvest regions. Along the Pacific Coast there are trap tiers ranging from 350 to 500 traps per vessel based on catch history (personal communication, L. Veneroso, Shellfish Policy Leader, Washington Dept. of Fish and Wildlife).

If the industry wants to significantly reduce the total amount of gear in the water, additional measures that "ratchet down" the trap limit may be necessary. Some form of trap certificates, similar to those implemented in the Georgia blue crab and Florida spiny lobster fisheries (CFAC 1997; Larken and Milon 2000) might eventually need to be considered. Such a system would involve setting a total number of traps to be used by the fleet and issuing certificates (one per trap) to be placed on each trap by fishermen. The number of certificates could be reduced each year until the desired fleet-wide total is reached. Certificate transferability and geographic specificity could also be included.

Some form of trap limits is the alternative management tool most likely to be implemented because of the high level of approval among fishermen. Trap



California Dungeness crab fishermen were surveyed about new management measures to distribute the catch more evenly throughout the season. The majority — except large vessel owners — support the establishment of limits on the number of traps per vessel. Commercial fisherman James Gullett and Humboldt State University student Aaron Bliesner pull traps on the Humboldt County coast.

limits may be implemented together with other restrictions such as daylight-only fishing and trap limits that differ between central and Northern California. The recently implemented buyback of trawlers (December 2003) administered by the National Marine Fisheries Service (NMFS) included 23 large vessels that also fished for crab in California (U.S. Congress 2003). Fishermen remaining in the trawl, pink shrimp and Dungeness crab fisheries will repay about 80% of the cost of this buyback to NMFS. This 27% reduction in large vessels that fish crab may change the dynamics of industry discussions about trap limits.

Quota systems. Quota systems would assign specified harvest rights for a proportion of the total allowable catch to individuals or communities. They are generally perceived unfavorably by all sectors of the crab industry. In theory and in practice, however, these harvest-rights systems create incentives that slow the race for fish and shellfish and provide opportunities for innovative marketing to add value (Casey et al. 1995; NRC 2001); both results might improve the economic performance of the fishery. With assured access to a proportion of the total catch, quota holders could time their fishing and configure their fishing operation to maximize profitability. Some processors currently are able to do this to some degree by freezing crab harvested early in the season and then processing and selling the meat during the year to meet high-value demand by restaurants (see sidebar, page 190).

Survey respondents were concerned about the potential excessive aggregation of harvest rights and difficulties in making the accurate annual crab

abundance estimates needed to set individual or community quotas. If quota systems were ever implemented, these concerns would have to be addressed. In addition, individual or community quotas would have to be specified geographically to be effective.

Given the current unfavorable opinion of quota systems, they are unlikely to be considered seriously in the near future even though they would likely slow the pace of the fishery. The Pacific Fishery Management Council's fall 2003 decision to examine individual fishing quotas for the groundfish trawl fishery could influence future knowledge and attitudes about quota systems in the crab fleet. The British Columbia (Canada) groundfish trawl fishery has operated profitably in recent years under an individual quota system. This has provoked a high level of awareness and interest from the U.S. Pacific Coast trawl fleet. The council conducted public scoping meetings on trawl fishery individual quota systems during summer 2004.

Regional or zonal management.

Owners of larger vessels tend to view spatial management unfavorably. Their comments indicated a desire to move freely throughout the state to take advantage of the earlier season opening in central California as well as to maintain flexibility in their operations. Some fishermen would like to see trap limits only for central California and a uniform season opening date statewide. We feel that regional differences are likely to be part of any changes in crab management because crabs are usually more abundant in Northern California and the northern vessels, on average, are larger.

Daylight-only fishing and one trap-haul per day. These two management

tools could be used to slow the fishery by reducing the fleet's fishing efficiency and harvest capacity. Not surprisingly, daylight-only fishing was significantly more popular with smaller vessel owners for whom night fishing is impractical and risky. Daylight-only fishing would reduce competition from large vessels that can fish many more traps, 24 hours per day, and in adverse weather conditions.

Where is the fishery headed?

This study clearly shows that the majority of the vessel owners favor some type of trap limits and some limitations on fishing at night. The larger, higher producers, who are fewer in number, tend to view further restrictions negatively, as hampering their ability to fully utilize their harvesting capacity. These decades-long differences in opinions due to vessel size continue to make management changes difficult.

The most likely near-term outcome is the adoption of some form of trap limits, at least on an experimental basis. The crab fishery in Washington recently adopted tiered trap limits and Oregon is seriously considering them. If Oregon implements trap limits, excess gear from Oregon could wind up being used in California and further intensify the fishery, pushing California toward trap limits.

Any trap-limit program should be closely evaluated after implementation. Other than preventing explosive growth in the amount of gear fished, a single level of trap limits (250 traps per vessel is proposed in current pending legislation) alone would likely have little effect on the overall fishery other than some transfer of catch from larger operations to smaller ones. As in many other common-pool natural resource

settings, the potential for redistribution of profits serves as a potent barrier to change (Hackett 1992).

If the fishermen's goal is to reduce the total amount of gear fished significantly below the current total of approximately 170,000 traps, some plan for systematically lowering total trap numbers will be needed. Some options include:

Trap certificates. Transferable or nontransferable certificates could be used that fit under an overall statewide or regional trap total. This total could be adjusted downward in an orderly fashion over the years to reach a generally acceptable number. Setting a target trap total(s) at the beginning of the process may help fishermen to accept the program.

Vessel trap limits. Limits could be set lower each season until reaching a target level. Larger vessels would likely oppose this approach. Trap limits could be scaled to vessel size.

Buy out. Those interested in leaving the fishery would receive a monetary payment similar to the recently implemented trawl-fleet buyback through a government loan. Those remaining in the fishery would reimburse the government over time. Some restrictions on traps would be needed to prevent excessive expansion by those remaining.

Harvest-rights system. Transferable or nontransferable rights would allocate a proportion of the overall allowable catch to each fisherman. This could slow the race for crabs and provide incentives for fishermen to make their individual businesses more efficient. It would require improved estimates of crab abundance, improved enforcement, quotas within geographic zones and agreed-upon quota aggregation limits.

Status quo. Let attrition under the current restricted-access program gradually reduce fleet size and perhaps the number of traps fished. This would likely take many years.

Trap limits appear to be the only alternative with a likelihood of adoption in the near term, but the long-term consequences of that approach are unclear.

Why haven't management tools used elsewhere in the world been seriously considered in California? It could be because trap limits have been considered and debated in great depth for many

years. Fishermen, processors, DFG staff and key legislators have high awareness and knowledge about this approach compared to other alternatives.

Rogers (1995), in summarizing the large body of research about the adoption of new technologies and practices, demonstrates that people go through a series of stages in their process of adoption or rejection. Crab fishery participants are clearly well along in this process for trap limits and have developed perceptions of their relative advantages or disadvantages. However, many of these same participants have not been as focused on alternative management tools and are not as far along in the adoption/rejection process for them.

In addition, the California legislature — rather than the Pacific Fishery Management Council, DFG or the Fish and Game Commission — has primary responsibility for policy related to the Dungeness crab fishery. (The U.S. Congress transferred this authority to the individual state legislatures in 1996.) The long-term lack of industry consensus has made management changes by the legislature difficult in the past and is a likely barrier to alternative management approaches in the future, with the possible exception of some form of trap limits. If trap limits are adopted in the near future, but do little to solve perceived problems in the fishery, then it is possible that industry, fishery managers and the legislature will focus their attention on additional management options.

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Conserving California fish . . .

Extension approaches applied to contentious marine-fisheries management issues

Christopher M. Dewees
Kristen Sortais
William S. Leet

We describe three creative collaborations between the California Sea Grant Extension Program (SGEP), the California Department of Fish and Game, the fishing industry and university researchers to improve marine fisheries management in California. These collaborations involved difficult and long-standing issues at a time when many fisheries are declining. The cases studied highlight SGEP's involvement in (1) implementing California's comprehensive marine-life management legislation, (2) helping the sea urchin industry identify goals and techniques to achieve them, and (3) using extension methodologies to enhance socioeconomic research related to management of the Dungeness crab fishery. Critical components of SGEP methods were trust, independence and nonadvocacy, a science-based approach, and effective communication. These characteristics are seldom found together among diverse participants involved in contentious fisheries-management situations. We demonstrate how extension programs can partner with constituents and agencies to improve the management and research process; this approach can be applied to the broad range of natural-resource issues facing the state.

Marine fisheries nationally and in California have a long history of producing significant commercial and recreational benefits. Commercial fishing is the last significant industry where participants hunt and harvest wild organisms. Fisheries resources



With some Pacific fisheries in decline, marine management issues are often contentious. In Bodega Bay, an old trawler rests on its mooring.

are common property, and with few exceptions participants do not have exclusive harvest rights. Fishermen are primarily small-scale, individual, owner-operators of vessels who compete intensely for a limited renewable resource in California's extremely variable marine environment.

Over the past 30 years, the fishing industry has evolved from the development and expansion phase to recent declines in production and participation. The industry is challenged by the closure of some fisheries and fishing locations, increased regulation and

restrictive management mandated by federal and state laws, reallocation of fisheries resources to other users, and an increase in large areas set aside as marine reserves. Perceiving these threats to their livelihoods, the fiercely independent industry participants now tend to have adversarial or untrusting relationships with agencies and outside groups involved with fisheries management, making these issues increasingly contentious and difficult to resolve.

As the fishing community's needs changed, the focus of UC Cooperative Extension's Sea Grant Extension Pro-

gram (SGEP) switched from increasing fishing production to emphasizing fisheries management, conservation, fuel efficiency, value-added products and the evaluation of techniques for reducing harvest capacity. Administered by UC, California Sea Grant sponsors research on marine-related issues and problems, and transfers that information via extension to industry, government and the public.

SGEP has built a reputation as a trusted, nonadvocacy source of research-based information and assistance to those involved in today's critical fishery-management issues. This capability gives SGEP a relative advantage in helping improve fisheries management in California.

This paper describes three different collaborative approaches involving SGEP, the California Department of Fish and Game (DFG) and the fishing industry: implementation of a comprehensive, new, state marine-life management law; development of science-based information for a plan to better manage the sea urchin fishery; and evaluation of management options for the Dungeness crab fishery. In all three, trust among participants and SGEP's nonadvocacy approach were key elements. The approaches used in these cases are directly applicable to other contentious natural-resource issues (such

as wildlife management, forestry and land management) and high-conflict situations.

California marine fisheries

Marine commercial fisheries have changed dramatically over the past 30 years. During the 1970s, expansion of fisheries, opening of new fisheries, technology transfer and increased production were emphasized in response to national policy initiatives. These initiatives were effective in creating high harvesting capacity (Weber 2002). Today, a top fisheries-management priority is reducing this harvesting capacity to a level that more closely matches sustainable catch levels.

Between 1981 and 1999, California's commercial fishing landings declined from 791.4 million pounds to 472.1 million pounds and in value (1999 dollars) from \$475.7 million to \$144.4 million (Thomson 2001). Much of this decline was due to the shift in tuna landings to less costly ports in American Samoa and Puerto Rico, as well as declines in the landings of rockfish, urchin, salmon, abalone and other species. At the same time, harvests of squid, lobster and sardines expanded. Thomson (2001) reported that expenditures by recreational marine anglers averaged \$506.9 million in 1998 and 1999, but in general participation has declined in recent years.

Between 1981 and 1999, the number of commercial fishing vessels that land fish in California declined from 6,897 to 2,690 (Thomson 2001). Many of those remaining adopted new technologies (especially fish-finding electronics) to compete. In addition, fisheries such as those for salmon and sea urchin faced declining prices due to increased supplies and competition from aquaculture and other countries (Leet et al. 2001).

Marine Life Management Act of 1998

In response to growing concern among environmental groups, scientists, citizens, legislators and some fishing groups about declines in marine and estuarine fisheries, the California legislature passed the landmark Marine Life Management Act (MLMA) of 1998 (Weber and Heneman 2000). Key elements of the MLMA include:

- Switching responsibility for marine fisheries management from the state legislature to the Fish and Game Commission.
- Mandating a Status of Fisheries Report with annual updates.
- Requiring DFG to develop fishery management plans (FMPs) and research protocols to fill information gaps.
- Requiring scientific peer review of documents and a high level of constituent involvement.

Soon after the MLMA became law in 1999, the DFG realized that they did not possess all the scientific expertise and research-based information needed for its successful implementation. SGEP decided to become involved because we believed that extension techniques could be used to significantly improve the state's ability to manage its marine fisheries.

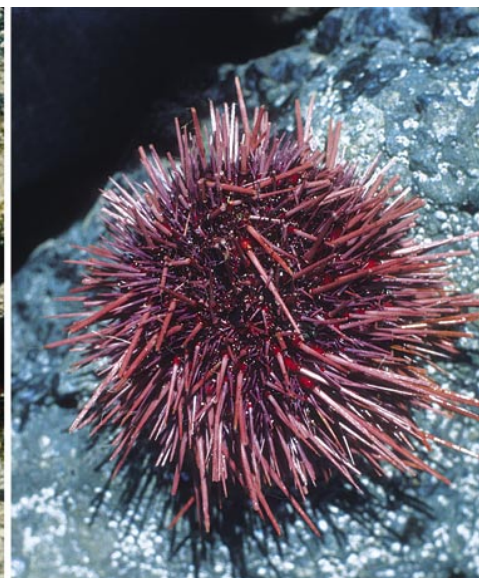
Training. With DFG funding, SGEP conducted training workshops for DFG Marine Region staff on managing near-shore fisheries and conducting collaborative research with constituents. SGEP brought in fisheries scientists, agency staff and commercial fishermen from around the country to share their experiences and provide near-shore case studies from Alaska, British Columbia, Washington, Oregon and Maine. The 2-day training workshop helped DFG staff form concepts for drafting the



UC Cooperative Extension's Sea Grant Extension Program has long taken a lead role in finding collaborative solutions to difficult fisheries-management problems in California. Marine advisor emeritus Bruce Wyatt (center) consulted with a fishing couple about the Dungeness crab fishery.



Sea Grant advisors provided technical assistance and training to regulators on the peer-review provisions of the Marine Life Management Act of 1998. Under the state law, the kelp greenling, above, is managed under a complex fishery-management plan developed for near-shore fishery resources, which was implemented in the 2002-2003 season.



In the late 1980s, the California sea urchin industry imposed a landings tax on itself, raising more than \$1 million for research and management activities. Sea Grant advisors facilitated statewide meetings to identify fishery goals.

mandated, highly complex near-shore FMP and strengthened DFG staff collaboration with university scientists and other state-agency personnel. The near-shore FMP was adopted by the California Fish and Game Commission and implemented during the 2002-2003 fishing season.

The training on constituent involvement and collaboration was less successful. We failed to include examples of collaboration with recreational fisheries participants, which some DFG and external constituents perceived as a bias. DFG continues to struggle with constituent involvement, although they have recently initiated collaborative fish-stock monitoring programs with fishermen, divers and others.

Fisheries report. With DFG staff and more than 100 outside authors and reviewers, SGEP designed, edited, compiled and published the peer-reviewed *California's Living Marine Resources: A Status Report* (Leet et al. 2001), modeled after SGEP's *California's Living Marine Resources and their Utilization* book (Leet et al. 1992). This publication serves as the primary reference for managers, policymakers, journalists, students, industry and interested citizens about California's marine ecosystems, fisheries, aquaculture and other marine organisms. The Web version received

approximately 25,000 hits during the first 16 months, with users often downloading individual sections.

Peer reviews. SGEP facilitated, designed and carried out independent, external, scientific, MLMA-mandated peer review of proposed FMPs for the white seabass, near-shore and squid fisheries, as well as the Abalone Recovery and Management Plan (Leet et al. in press). We submitted summaries of the review panels' primary findings to the DFG and Fish and Game Commission. DFG used detailed and technical reports from individual review-panel members to guide their revisions. Significant improvements were made to the plans based on the peer reviews and constituent comments. As of this date, the Fish and Game Commission has approved the white seabass, near-shore fisheries and abalone plans and is reviewing the final squid plan for possible adoption in late 2004.

We learned several key lessons from our involvement in the MLMA peer-review process. First, SGEP's independence in selecting and conducting science reviews is critical to avoid either the agency or constituents from trying to influence the outcome. Even a perception of outside influence makes the process difficult. In addition, DFG staff need to increase their

understanding and effective use of scientific and constituent review of FMPs.

However, current and projected budget shortfalls for DFG are greatly slowing effective implementation of the MLMA. Nonetheless, SGEP continues to provide training to DFG and constituents, which will improve their capability to utilize outside scientific review and expertise successfully when resources are available to resume MLMA implementation.

The sea urchin fishery

The fishery for red sea urchin (*Strongylocentrotus franciscanus*) began in the early 1970s and has been one of the state's most valuable since the mid-1980s. Urchins are harvested by commercial divers for their gonads, which are marketed primarily in Japan. Annual landings peaked in 1988 at 52 million pounds, worth approximately \$20 million to fishermen. From 1995 to 1999, annual landings averaged 17.04 million pounds worth \$16.15 million, representing 4% of statewide commercial fishery landings and 10% of the revenue fishermen receive for their catch (ex-vessel value)(Thompson 2001). Intense fishing, unfavorable ocean conditions and difficult markets combined to reduce landings (Deweese 2003).

Recognizing the explosive growth in the fishery and the need for manage-

ment, the sea urchin industry and DFG created the DFG Director's Sea Urchin Advisory Committee (DSUAC) in 1987, with funding from an industry-imposed landings tax. More than \$1 million was raised for research, enhancement and management activities. Between 1987 and 1993 almost all of the current management system was developed collaboratively by the DSUAC and DFG.

By 1993, concern about the status of the urchin fishery motivated DFG to draft an FMP. This plan was not well received by industry or a jointly selected science review panel. Collaboration, communication and momentum waned after 1994, and in 2001 DSUAC was disbanded. However, the urchin industry continues to have a strong interest in collaboratively constructing a workable management plan to ensure a biologically sustainable and profitable fishery. The MLMA provides the structure for doing this.

Christopher Dewees, UC Davis marine fisheries specialist and a DSUAC member from 1987, was familiar with the difficult issues facing the fishery. In consultation with the industry and DFG, SGEP facilitated a series of meetings statewide, in August and September 2002, to help the industry identify and prioritize goals, the precursor to designing a new management plan.

SGEP facilitated three all-day meetings about fishery goals with 45 sea urchin divers and processors. DFG

staff sat in as observers. The top goals identified included stock and fishery sustainability, and collaborative data collection and management with DFG. In addition, the industry supported the establishment of an effective industry organization to participate in DFG and commission meetings, organize participation in research and data collection, access fishery data, market product and improve the industry's public image.

To address the first two goals, the industry used funds remaining in the DSUAC landings-tax budget to hire a top shellfish ecologist (J. Prince, Murdoch University, Australia) and a top fishery-stock assessment scientist (R. Hilborn, University of Washington). In 2003, Prince and Hilborn designed an approach for resource monitoring and stock assessment that the divers could participate in as part of their regular fishing activities. The consultants spent 3 weeks diving and meeting with urchin fishermen, DFG biologists and university scientists, and high levels of idea sharing and trust were developed among participants.

SGEP's role was to help arrange meetings in the various ports among participants, and plan and facilitate an industry-DFG workshop to finalize suggestions for the consultants. Late in 2003, Prince and Hilborn provided the resource-monitoring plan to industry for consider-

ation. Data gathered by the industry could become a vital part of a future sea urchin FMP and potentially a good collaborative model for other fisheries.

The third goal of establishing an effective industry organization is progressing. Legislation was passed allowing the industry to form a state commodity board, which will assess members to fund research, management and promotional activities (similar to an agricultural commodity group). An industry-wide referendum on establishing this sea urchin commission passed overwhelmingly in late 2003.

We learned several key lessons from our work with the sea urchin industry. First, fishery participants trusted us enough to share their goals and then to accurately report that information to the rest of the industry, agency staff and others. Agency staff trusted us to work independently with fishery participants on management-related issues. Second, extension staff's ability to organize and facilitate collaborative meetings on complex and controversial issues was a key attribute.

Finally, these attempts at collaborative research and management would not have been possible without the willingness and ability of the urchin industry to tax itself and initiate the activity. Sustaining this effort will likely depend on the industry's willingness to fund collaborative studies. Increased profit-

John B. Richards



Because the California sea urchin industry was willing to work collaboratively with regulators and scientists, valuable monitoring data is being collected, which could inform a future fishery-management plan. *Left*, A sea urchin diver vessel in the Santa Barbara channel. *Right*, Sea urchin gonads are packed for shipment to Japan in a San Diego processing plant.

ability and the ability to sustain the tax assessment will be critical.

Dungeness crab fishery research

The fishery for Dungeness crab (*Cancer magister*) is conducted with baited traps from central California through Alaska. Since 1990 it has been the most valuable single-species fishery for the Pacific states of Washington, Oregon and California, according to the PacFin database of the Pacific States Marine Fisheries Commission. Crab abundance varies widely each year, and there is some evidence for cycles in abundance. Despite this high level of variability, most fishery participants and managers generally agree that the regulations for season, size, trap design and male-only harvest are protecting the resource from over-harvesting (see page 186).

However, the Dungeness crab fishery in California is characterized by its increasing intensity. California trap numbers have increased from an average of 29,115 during the 1971-1972 through 1975-1976 fishing seasons to approximately 175,000 during the 2000-2001 season. Currently, fishermen land approximately 80% of the legal-sized crabs during the first month (December) of the season compared with crab landings being spread out over the 7-month season before 1980 (Hankin and Warner 2001). The race for crabs results in crowding, fishing in unsafe conditions with loss of vessels and lives, conflicts between large and small vessels, oversupply of product early in the season, and intense price disputes. These conflicts have intensified in recent years as fishermen in other declining fisheries have increased their participation in crabbing.

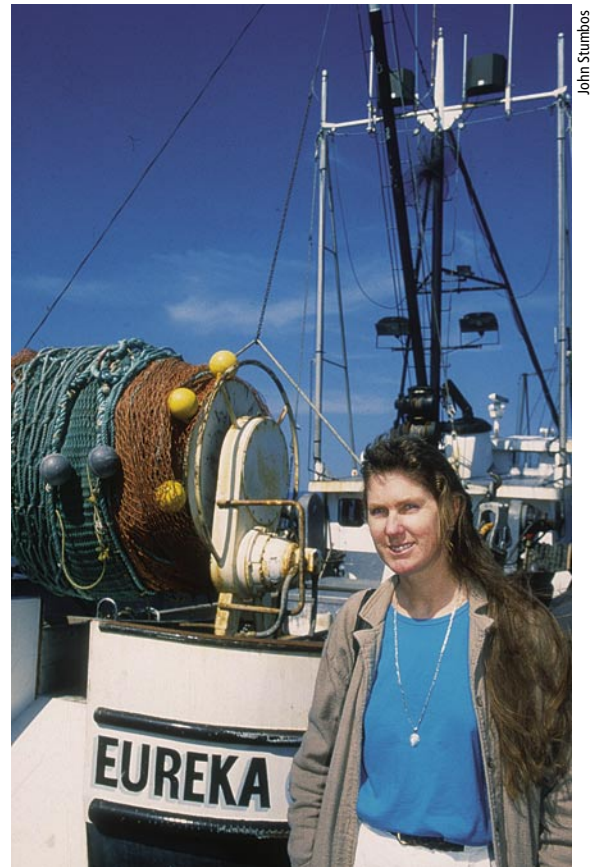
The industry recognizes these problems. In 1997, they implemented a license moratorium to prevent entry into the fishery. However, fishing pressure and conflict continues to intensify. Fishery participants have worked unsuccessfully to address these problems for the past decade, primarily by trying to set limits on the number of traps each vessel can use.

In 2001, California Sea Grant funded faculty from Humboldt State University and the Sea Grant/Cooperative Extension marine fisheries specialist to conduct a 3-year study on the fishery. One major goal was to identify feasible alternative management techniques to increase the fishery's net economic benefit. Involvement of the extension component was essential to secure industry participation on a project investigating such contentious issues.

This collaborative faculty-Cooperative Extension effort started with a worldwide review of management approaches used to address similar problems in other trap fisheries targeting crustaceans. Focus-group meetings were conducted in key ports to obtain industry input and involvement in comprehensive surveys of crab fishermen and processors. Later, the researchers hosted port meetings to present and discuss survey results with crab permit owners, testified before the state legislature's fisheries and aquaculture committee, and initiated publication of the processing-sector analysis (Hackett et al. 2003) and fishermen survey results. (see page 186, 190)

The review of management methods used around the world in similar fisheries gave fishermen the opportunity to think about and discuss alternatives to the status quo or the much-debated trap-limit approach, and we were able to measure fishermen's perceptions of those alternatives in the survey. While trap limits were the preferred alternative, we pointed out that they do not necessarily reduce the total number of traps if the maximum limit is set too high (Acheson 2001).

The survey had a 40% response rate; by comparing respondents with the industry-wide demographics, we determined that our sample was representa-



California Sea Grant advisors have learned that they must maintain their independence, not be perceived as advocates for a particular side and pursue science-based solutions. Susan McBride, a Eureka-based marine advisor, leads collaborative research projects with commercial fishermen.

tive of the entire fleet. Generally, the highest response rates were from ports where we conducted focus-group meetings before the mail survey. We believe that increased awareness of the project, participation in survey design and trust built up by the focus-group meetings improved the questionnaire return rate.

Fishery participants, agency staff and policymakers can use the data collected on fishery activity, economics, demographics and perceptions of management approaches for negotiations on future management changes. Legislation is likely that may include proposals for some form of trap limits, zonal management and daylight-only fishing. Washington state has already implemented trap limits and Oregon is considering them.

Two key lessons from this case are that collaborative research by extension and research faculty on contentious human dimensions of resource

Commercial fishing is the last significant industry where participants hunt and harvest wild organisms.

issues is significantly enhanced by the knowledge, trust and nonadvocacy approaches that extension faculty supply; and involving industry participants in project design appears to increase the relevance and credibility of the results among participants.

Contentious management issues

These three cases involve highly contentious marine-fisheries management issues in which extension has been able to play a key role in the search for potential solutions. The MLMA implementation case covers the state's fishery management system in general, while the other two examples involve specific, valuable, individual fisheries. A common thread across all three was a high level of mistrust of the management agency among constituents.

We took different approaches in each situation. The MLMA mandated that scientists review the science in management plans. DFG, industry and other constituents were relatively inexperienced with outside review, so we decided to include DFG training as part of our approach. We are also compiling recommended peer-review procedures for the DFG to use with future FMPs. We hope that in the long term, these actions will increase the agency's ability to incorporate outside research-based information and review into their resource management planning.

Our decision to use facilitation as the primary method with the sea urchin industry was based on our long-term involvement with the industry. We observed that divers, processors and DFG needed to identify specific goals for an FMP. Once these goals were identified, it expedited the formation of a Sea Urchin Commission and the development of collaborative, industry-based resource assessment protocols. Our primary goal is to strengthen the organizational and research capabilities of the sea urchin industry, leading to improved integration with DFG and academics. We hope that a collaboratively developed FMP is the end-result.

Our reason for choosing a research approach with the Dungeness crab industry was based on the need for independently collected socioeconomic data and opinions on management alternatives, to inform the industry's discussions of proposed management changes. Debate between large and small vessel owners is often highly contentious, and this information will be important to the design and discussion of any future legislation.

In these three marine fisheries cases, Cooperative Extension's Sea Grant staff had four relative advantages. These characteristics illustrate the unique role that extension can play in contentious natural-resource issues. Industry, agencies and nongovernmental organizations often lack some of these attributes. The lessons from these three cases are certainly applicable in nonmarine natural-resource settings as well as agricultural and human resources problems.

Independence and nonadvocacy. If you advocate on an issue, or are even just perceived as an advocate for one specific solution or one stakeholder group, you quickly lose credibility with the other involved groups. This was particularly critical with the MLMA peer-review process, where we had to remain stridently independent to avoid the perception of being aligned with the management agency. The same was true with our crab fishery research. Both the reality and perception of being an "honest broker" is key to success.

Trust. This is earned by sustained honesty and follow-through on promises. In these three cases, all stakeholders needed to trust us to conduct independent peer reviews, protect confidentiality, not advocate and deliver promised products.

Effective communication. This is needed to avoid misunderstanding, promote an open exchange of ideas, assure inclusiveness and increase participation. Extension staff often has an excellent understanding of formal and informal communication channels, and we used this to enhance project success.

Science-based approach. Bringing in outside scientists to review manage-

ment plans independent of the agency and stakeholders has advanced both the quality and acceptance of the science in California's FMPs. In the sea urchin case, collaboratively developing stock-assessment research protocols is likely to lead to increased data collection and reduced controversy about the validity of this data. The crab fishery research example demonstrates that partnerships of extension staff and campus faculty in human-dimensions research can improve the quality, relevance and acceptance of the results.

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Davis school program supports life-long healthy eating habits in children

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The school environment can positively affect students in areas beyond traditional academic achievement. An innovative program in Davis, the Farm to School Connection, sought to promote the development of life-long healthy eating habits in children and to create a school environment that made connections among the school garden, cafeteria and classroom, and linked them to local agriculture. This comprehensive program included farmers' market salad bars, classroom education, farm tours and waste management. We evaluated the effectiveness of the program via interviews and surveys of program leaders, teachers and school staff. Participation in the school lunch program increased with the addition of the salad bars, and numerous partnerships developed among those involved. Components of the Farm to School Connection provide evidence to support comprehensive school nutrition programs and the positive impact they can have on the school environment.

At a time when childhood overweight and obesity are at record highs, educators can utilize the school environment to link schools with families and communities, in order to promote healthy lifestyles and prevent obesity and associated diseases. The percentage of children in the United States who are overweight increased from 7% in 1980 to 15% in 2000, and the percentage of overweight adolescents increased from 5% in 1980 to 15% in 2000 (Ogden et al. 2002). In California,

34% of children and 21% of adolescents are overweight or at risk for overweight (Foerster et al. 2002). Obesity or overweight status places individuals at risk for several chronic health problems (CDC 2003; Epstein et al. 1985; Rosenbaum et al. 1999; Whitaker et al. 1997). Obesity not only adversely affects health, it can also negatively affect a child emotionally and socially. Obese children and adolescents often have a lower health-related quality of life as compared with nonobese, healthy children and adolescents, affecting their ability to participate in normal social behaviors, such as sports and playground activities (Schwimmer et al. 2003).

One prudent step toward improving child health is for schools to move beyond their traditional academic role to take an active role in promoting healthier lifestyles, families and communities.



Lyra HalprinUC SAREP



In Davis elementary schools, children can choose what they want for lunch from salad bars stocked with healthy fare, including fruits and vegetables supplied by regional growers.

Photos: Jeri OlmarUC SAREP

The U.S. Centers for Disease Control (CDC) encourages creating a school environment that supports regular physical activity and healthy eating habits (CDC 1996, 2003). This includes ensuring quality meal service for students, monitoring the sale of competitive foods and providing an environment that promotes good health.

Bringing agriculture into schools

In the past, Americans were more aware of the important role farming played in their lives. Many worked on farms or lived in farming communities. Today, however, most people live in urban areas. Although California still has bountiful agriculture, fewer and fewer of its residents are aware of the impact farming has on their lives. Children, especially, have lost touch with how and where food is grown. They lack an understanding of the ecosystems, the land, the people and even the plants that produce their food (CDE 2002).

Many school districts throughout California have shown an interest in “stepping out of the box” of traditional teaching methods to incorporate agriculture into the school environment (Graham et al. in press). The incorporation of agriculture into the school curriculum provides an excellent avenue in which to discuss food — where it comes from, its health benefits, how to choose healthy foods and factors contributing to human health, as well as concepts important to planetary health, such as composting and recycling.

We describe a comprehensive model program initiated by the Davis Joint Unified School District (DJUSD), which incorporates agriculture into the school environment. This program embraces a “seed to table” philosophy, in which every part of the school environment, from gardens to the cafeteria to the classroom, are part of a consistent and repetitive message to students — that healthy eating habits can be learned through participation in the full cycle of life from seed to table and back again. The environment is used as the focal point for learning, as environmentally based learning has been shown to be an effective route for enhanced learning, resulting in higher grades and

improved standardized test scores (Lieberman and Hoody 1998).

In 1999, the Davis Farm to School Connection was formed with the assistance of various community and government organizations including the Davis Farmers’ Market, DJUSD, UC, Davis Children’s Garden, Yolo County Office of Education, UC Sustainable Agriculture Research and Education Program (UC SAREP), California Department of Education (CDE), California Integrated Waste Management Board (CIWMB) and Community Alliance with Family Farmers (CAFF). Formal evaluation of the program took place from 2001 through 2003.

The program initiated farmers’ market salad bars, first in three and later in all DJUSD elementary schools; this provided an opportunity for local farmers to expand their markets by selling produce to the school district. The program offered farm tours to second-grade classes, used established instructional gardens for hands-on learning experiences included recycling and composting, and integrated classroom curricula with garden activities and farm tours.

In addition, the garden “laboratory” was integrated with nutrition education, because garden-enhanced nutrition education is an effective avenue to improve children’s knowledge of nutrition and vegetable preferences (Morris and Zidenberg-Cherr 2002).

Farmers’ market salad bars

In 2001, the first three farmers’ market salad bars, termed “Crunch Lunch,” were established in three elementary schools, featuring fresh fruits and vegetables (organic when possible) purchased directly from regional growers. The salad bars were designed for students to serve themselves from a variety of fresh vegetables, fruits and protein sources (beans, tuna, turkey and cheese). Students were usually allowed to return to the salad bar, which was the same price as the standard hot lunch. During the first 2 years, Crunch Lunch was offered as a separate option to the hot lunch meal 5 days per week. In the third year, the model was changed to an integrated salad bar/hot lunch option in which the salad bar was offered with the hot lunch every day.



Jeri Ohmart/UC SAREP

At the Birch Lane Elementary School in Davis, students keep animals as part of the Farm to School Connection. Other components of the program include farmers’ market salad bars, farm tours and garden-based education.

The Farm to School Connection serves as an example of how incorporating agricultural concepts within school curricula can facilitate teaching to core curriculum standards for math, science, language arts and social science.

Overall, Crunch Lunch has been popular with the students, and participation in the school lunch program has increased. In a recent review, participation was measured based on the number of enrolled students who purchased lunch from the salad bar. Participation in the three salad bar schools was greater (37.4%) than in non-salad bar schools (27%) during the 2001-2002 school year (September to June). Participation moderated somewhat during the 2002-2003 school year, to about 33% in salad bar schools compared to 26% in the non-salad bar schools (Feenstra and Ohmart 2003).

The amounts of fruits and vegetables children took from the salad bar declined somewhat in the third year when the model changed to an integrated salad bar/hot lunch. Program leaders suspect that this may have been partly due to a diminished focus on the salad bar as the centerpiece of the meal and the fact that there is less room on the plate for the salad when there is a hot entrée. The novelty of the salad bar may also have worn off since it was available every day. As of this writing, the food-service staff is considering changing the model again to “salad bar only” on the days the salad bar is offered. This model has been extremely popular in other school districts such as Winters and Ventura (Feenstra and Ohmart 2003).

Staff perceptions of salad bars

During the 2001-2002 school year, we interviewed staff for their perceptions of the salad bar as well as to assess partnership development among DJUSD staff involved in the program. The interviews included questions on the effect of the salad bar on the school environment; whether the program has affected work flow; how the salad bar affects student diets; how the salad bar is working in terms of staff and logistics of preparation, delivery and service; positive and negative effects since the program started; training received for initiation of the salad bar; and any present or future challenges. Food-service

staff were also asked one additional question specific to preparation and service of the salad bar.

Staff members at the three pilot school sites were asked to voluntarily participate in the group interviews. They included staff directly involved with the gardens at one or more sites ($n = 8$), teachers ($n = 7$) and food-service staff directly involved with preparation and service of the salad bar ($n = 3$). Three separate groups were interviewed, and the different types of staff were interviewed separately (garden, teachers and food-service). A moderator facilitated the semistructured discussions and an assistant recorded responses. All interviews were audio-taped and written notes were taken. The transcribed interviews were analyzed to identify common themes within each group and as an entire group. All procedures were reviewed and approved by the UC Davis Committee on the Use of Human Subjects, as well as the DJUSD. Recurring themes were identified, with special attention paid to the participants' responses to the seven or eight questions.

Student diets. Participants noted that they saw an overall positive effect on the students' diets and that the children were excited about having a salad bar as a lunch option. One staff member stated “students will switch from hot lunch if they see items they like in the salad bar.” Others noticed that children often discarded their vegetables when eating a hot lunch, but did this less often with the salad bar.

Choices and portions. Teachers stated that they liked the idea of the children having the independence to make their own choices and learn about portion sizes. There was concern about children putting enough food on their plates. Some teachers believed that knowledge of portion sizes among students was lacking and that guidance in making food choices was essential. Two teachers stated that some students placed too much on their plates, leading to unnecessary food waste. Food-

service staff noted that additional training would assist them in gaining knowledge of serving sizes in order to better assist the children in making adequate choices. One food-service staff member stated that information was needed on “what a serving of strawberries looks like.” Another noticed effect was decreased plate waste.

Cafeteria environment. Participants stated that the lunch period was “calmer” with the addition of the salad bar. It was also mentioned that lunch became more social among students, who discussed the foods on the salad bar. Overall, those interviewed noted that the salad bar lines were long. All felt that improving the speed and efficiency of the line was needed.

Work flow. Teachers and garden coordinators stated that the salad bar program did not adversely affect their flow of work. Food-service staff reported a consistent need to work overtime in order to complete all duties for the salad bar, including an estimated 30 additional minutes for cleanup duties.

Leftovers. Food-service staff stated that they preferred to store leftovers at the school site for convenience, organization and the assurance of food safety, and because a delivery truck used to transport food to a storage space in the high school had no refrigeration unit. One staff member noted that it would be helpful to have proper storage procedures for leftovers. They also noted that there was not enough space to store salad bar items at the elementary schools.

Sustainability and partnerships. A major question raised by those interviewed was, “Can [the salad bar] pay for itself?” Some issues mentioned in relation to sustainability included: having adequate and consistent volunteers, managing labor costs and maintaining the quality of the salad bar without “cutting corners.”

Garden coordinators and teachers agreed that their communication with parents was enhanced, particularly those involved in the school garden. However, one individual stated that more education about the salad bar

These comments illustrate the complexity of introducing the program, the need for staff and student training on the use of the salad bar, and reasons why it is necessary to market the program to increase student participation.

Attitudes and knowledge. Nutrition-related attitudes and knowledge were assessed using six scale questions, with answers ranging from 1 to 5. When asked about the importance of providing nutrition education in the classroom, 84% rated it as “moderate” to “very” important, while 16% said it was “somewhat” important and none said it was not important at all.

Classroom incorporation. Overall, nutrition was incorporated into the classrooms of 69% of teachers responding to the questionnaire. Due to the variability of nutrition topics taught among schools, this data is reported for individual schools (table 1). Eighty-six

Barriers. The top three barriers to incorporating nutrition in the classroom were lack of time (79%), lack of curriculum linked to standards (61%) and lack of available resources (44%). One teacher wrote: "There is not enough time to also teach nutrition. The state is too focused on core subjects and testing scores." As for the garden, 67% said that time was the largest barrier to using the garden to enhance academic instruction.

Composting, waste reduction. The DJUSD piloted food-waste composting systems at the three



Dorothy Peterson, garden coordinator for the Davis school district, speaks to a group from the California Integrated Waste Management Board about the Farm to School Connection at Birch Lane Elementary School. Through the program's Food Waste Diversion Project, students learned to recycle lunch wastes and create compost for the garden; the gross savings from two schools was \$6,230 in disposal fees during one school year.

pilot schools during the 2000-2001 school year, under a contract with the CIWMB. The goal of the Food Waste Diversion Project was to develop and test site-specific systems to reduce the lunch waste stream and in particular to reduce the food components of lunch waste while engaging students in the ongoing practice of composting and recycling.

The program generated a gross savings of \$6,230 in disposal fees alone from waste reductions at Cesar Chavez and Pioneer schools. As of spring 2004 the composting program had been updated based on program plans and extensive fiscal data projections presented by the DJUSD garden coordinator, and it had become self-sustaining and expanded to all eight elementary schools within the district.

Farm tours. During spring 2002, 10 second-grade classes at two schools took daylong field trips to local farms, organized by CAFF's Farm to School coordinator. A classroom lecture tied to

grade-level subject standards preceded the field trips, which provided hands-on learning and established connections between the garden, the salad bar, recycling, and the food and farming system. Teachers reported that the trips reinforced class time with real-life examples and experiences, and said that they would like to take their students on similar trips in the future.

CSA boxes. Another educational component of the Farm to School Connection was the provision of community-supported agriculture (CSA) boxes obtained from local farmers. Boxes of farm fresh fruits and vegetables were donated to the three schools involved in the pilot program for use in classroom cooking sessions, science lessons or other educational purposes, such as nutrition education and art.

Challenges and future directions

Now in its fourth year, the Davis Farm to School Connection continues to evolve as it becomes more integrated

into educational program delivery in schools within the district. School districts may use the information from this program to develop and enhance their own learning environments. Furthermore, this program serves as an example of how incorporating agricultural concepts within school curricula can facilitate teaching to the core curriculum standards for math, science, language arts and social science, an important aspect considering time constraints placed on teachers in California's current educational system.

The long-term mission of the DJUSD program is to integrate all parts of the seed-to-table cycle with activities and education, while furthering the district's educational goals for K-12. The instructional gardens and recycling components are fully integrated and self-sustaining at the elementary level. However, program development work is still necessary to achieve the mission, especially with Crunch Lunch and integration of education-related activities.

Crunch Lunch is still undergoing adaptations to achieve self-sufficiency and sustainability. A primary concern is keeping the expenditures for farm fresh produce within an acceptable food-service budget; a major challenge in the coming years will be to reduce costs or increase income. School lunch participation increased with the addition of Crunch Lunch, but further increases in participation are necessary to attain sustainability. Part of increasing participation in the salad bars is learning how to effectively integrate the lunch program, school gardening, recycling and nutrition/food education in the classroom.

Working with local farmers is a novel aspect of this program. It is essential that the individual who purchases produce for the salad bars is knowledgeable about farming, farmers' markets and building working relationships with farmers (Brillinger et al. 2003). Involvement of a forager in the past year to facilitate locating produce and communicate with the kitchen manager and farmers has been a positive addition to the program.

Agricultural, nutritional and environmental literacy for adults has surfaced as an important next step in creating a community climate that supports the concept of improving children's health. Data suggests that teachers perceive nutrition education as "somewhat" to "very" important; however, they also perceive it to be "somewhat" to only "moderately" feasible to incorporate into the classroom. In-service educational programs for teachers, including the use of curricula and activity guides that link farm-to-school components to the state's educational standards by subject and grade, were provided in spring 2004. Plans were also under way to engage community members in tangible ways by recruiting them as on-site volunteers.

Another consideration is developing and adopting related districtwide policies. District food policies can bring individuals together to support a common vision, facilitating focused efforts

on a healthy nutritional environment (Briggs et al. 2003). The California Superintendent of Public Instruction, Jack O'Connell, issued a challenge to all school districts in 2003 to pass and implement comprehensive nutrition and physical activity policies.

A healthy school environment has the potential to provide students with the ability to make informed decisions about dietary choices, possibly altering their eating behaviors as adults. With 27 million school-aged children participating in the National School Lunch Program, access to quality food in school is a critical nationwide component of providing them with the tools to make informed dietary decisions (Briggs et al. 2003). The comprehensive program in Davis is an example of what is possible in the school environment and the impact that individuals with vision and dedication can have on the health of children.

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Diet, shopping and food-safety skills of food stamp clients improve with nutrition education

Amy Block Joy

The California Food Stamp Nutrition Education Program (FSNEP) reaches approximately 50,000 families with children and individuals annually. Results from the 2001-2002 fiscal year demonstrated improvements in a variety of dietary and food-safety skills after clients received FSNEP training. In addition, results from a subsample (n = 460) showed significant improvements in the amount of money saved on food purchases, along with improved dietary quality. FSNEP provides food stamp clients with needed nutrition skills and promotes behavioral change to help them stretch limited resources. Program management practices have had positive effects on the program's overall operation and growth.

Food stamp families and individuals have a variety of nutrition-related needs, including to increase fruit and vegetable consumption, reduce fat intake, improve food-safety practices and increase skills in cooking, food shopping and utilizing limited resources (Joy and Doisy 1996; West et al. 1999; Murphy et al. 2001). The Food Stamp Nutrition Education Program (FSNEP) has assisted more than 500,000 California families and individuals to improve their dietary well-being since it began in 1994.

Administered by UC, FSNEP provides voluntary nutrition education to families and individuals in 42 California counties. Food stamp clients are enrolled in FSNEP and given 4 to 6 hours of intensive nutrition education in meal planning, food shopping and preparation, food safety and family economics. Major goals of the program include increasing fruit and vegetable consumption, decreasing fat and sugar intake,



Margaret Fields, program representative for UC Cooperative Extension in Los Angeles County, teaches the USDA food guide pyramid to food stamp clients.

preparing nutritious foods and shopping economically. This paper will focus on the dietary and food behavior skills of FSNEP participants in federal fiscal year 2001-2002 (Joy et al. 2002).

Improvements after FSNEP

Four dietary behavior measurements were taken in 1,447 clients enrolled in 14 counties (table 1). These results were collected by FSNEP nutrition assistants before FSNEP (pre-test) and then following 4 to 6 hours of nutrition education (post-test) using the Food Behavior Checklist (FBC); the diet-quality questions were validated (Murphy et al. 2001).

The FBC is a 21-item checklist that is self-administered before the nutrition education instruction begins (pre-) and at the end of the last lesson (post-). All enrolled participants are evaluated using the FBC. Each question has five choices (do not do; seldom; sometimes; most of the time; almost always) and pre- and post- results are compared to measure the change in the desired direction. Nine questions are on dietary practices; seven questions are on shopping,

planning and preparing food; two questions are on food safety practices; and three questions concern food security.

In our evaluation, the food stamp clients were from a diverse ethnic population: 42.50% Hispanic, 32.21% white, 18.12% black, 1.96% Native American and 5.21% Asian. The majority of participating FSNEP clients were female (82.00%).

Fruit and vegetable variety are associated with increased consumption of fruits and vegetables, while reducing soda consumption is associated with lowering sugar consumption. Removing chicken skin is associated with decreased fat consumption (Murphy et al. 2001). Mean improvements (range) in the 1,447 FSNEP clients evaluated for vegetable variety were 37.9% (21% to 67%); for fruit variety, 38.0% (11% to 57%); for reduction in soda consumption, 33.3% (17% to 48%); and for removing chicken skin, 30.8% (11% to 50%). These improvements demonstrate positive behavior changes in the families receiving nutrition education. A decrease in soda consumption together with an increase in fruit and vegetable

FSNEP offers a variety of simple ideas to help families prepare easy, quick, low-cost and nutritious meals.

TABLE 1. Improvements in dietary behavior of FSNEP participants in 14 counties, as measured by the Food Behavior Checklist

County	Number	Vegetable variety	Fruit variety	Drinking soda*	Removing chicken skin†
	 %			
Alameda	171	35	32	33	30
Calaveras	19	21	11	17	47
Contra Costa	65	51	31	42	50
Los Angeles	167	39	38	31	32
Placer	37	30	41	23	11
Riverside	118	36	32	31	26
Sacramento	140	40	40	27	38
San Diego	124	31	32	35	21
San Joaquin	119	31	41	44	23
Santa Clara	50	35	46	42	40
Solano	37	49	22	27	22
Sonoma	7	67	57	57	33
Stanislaus	223	42	40	27	31
Tulare	170	40	54	48	36
Total	1,447				
Mean‡		37.9	38.0	33.3	30.8

* Improvement measured by a decrease in the number of times participants reported this behavior.

† Improvement reflects low-fat eating practice.

‡ Mean percentage improvement in 1,447 clients.

TABLE 2. Improvement in food-safety skills in FSNEP participants, as measured by the Food Behavior Checklist

County	Number	Foods sit out*	Thaw foods*	Food-safety practices scale†
	 %		
Alameda	168	24	29	33
Calaveras	23	14	22	32
Contra Costa	65	37	74	83
Fresno	133	27	40	55
Los Angeles	163	26	51	62
Monterey/SB/SC‡	40	27	44	46
Placer	36	36	42	36
Riverside	118	24	47	57
Sacramento	144	33	40	53
San Diego	130	41	33	48
San Joaquin	144	19	55	60
Santa Barbara	6	33	67	67
Santa Clara	51	16	59	65
Solano	37	30	49	65
Sonoma	7	57	86	100
Stanislaus	225	25	37	49
Tulare	170	35	52	35
Total	1,660			
Mean§		28.0	44.3	51.1

* Indicators of good food-safety practices are measured by a decrease in the number of times food is left out of the refrigerator (foods sit out) and by an increase in the number of times food is thawed correctly (thaw foods).

† Food-safety practices score is a combination of FBC questions that look at storing, preparing and thawing foods.

‡ Monterey, San Benito and Santa Cruz counties.

§ Mean percentage improvement in 1,660 clients.

consumption are healthy dietary improvements.

Food-safety skills. FSNEP staff teach safe food-handling and preparation skills, to reduce the incidence of food-borne illnesses. The program offers instruction on a variety of food-safety skills and practices, with a curriculum for low-income populations called “Be Food Safe” (Kaiser 2001). We used the Food Behavior Checklist to measure a number of food-safety skills in 19 FSNEP counties (n = 1,660)(table 2). Each of the behaviors evaluated in the checklist are skills taught using the “Be Food Safe” curriculum.

In this population, mean improvements in these skills (range) were: decreased the number of times that food is left out of the refrigerator, 28.0% (14% to 57%); increased the number of times foods are thawed correctly, 44.3% (22% to 86%); and overall improvement by increasing the scores in a number of food storage and preparation practices, 51.1% (32% to 100%). The improvements reported in food-safety practices are important findings, since the incidence of food-borne illness is prevalent in this target population.

Economical food practices. Two counties (Los Angeles and Merced) collected 24-hour food-recall data on the

amount of money spent on food before and after receiving FSNEP instruction. The 24-hour food-recall is an evaluation instrument that collects data on an individual’s food consumption over a 24-hour time period. In Los Angeles County, recalls were collected on 167 FSNEP participants before (pre-) and after (post-) receiving nutrition education instruction. These participants are different from the ones reported in tables 1 and 2.

In Merced County, 293 participants re-

ceived nutrition education instruction by the Home Study method. In this delivery method, the first lesson is taught face to face and the rest of the materials (five lessons) are sent to the enrolled participant in the mail. The staff member contacts the enrolled participant by telephone to answer questions. The recall was done face to face (pre-) and then by telephone (post-). The Home Study method has been evaluated and is an effective approach to teaching families who are in remote locations (Lamp et al. 1999).

A FSNEP success story

I recently saw a former client at a local Asian restaurant. She is a tall, stately woman and was accompanied by her children, a grandmother and another friend with her children. She remembered me from a FSNEP class held at the local women’s shelter more than 7 years earlier. Since then, Hope (not her real name) had gotten her own place and become a counselor for a local substance-abuse program. She had been sharing nutrition information from my FSNEP classes, and told me how much the information had helped her. She asked if I would come and expand on those classes for her clients. It was gratifying to network with a former client who thought enough of FSNEP to share that information as well as ask me to educate others under her counsel. Hope and I now have a continuing working bond, as well as a personal one. I am very proud of this former client, who managed to pull resources together and move away from substance abuse and help other women. She has come a long way since our initial contact in FSNEP.

— Carolyn Gavanich, FSNEP Nutrition Education Assistant, Placer County

TABLE 3. Amount of money spent on food in FSNEP clients, Los Angeles and Merced counties

County	Number	Money spent on food		Change*
		Pre-test	Post-test	
	 \$		%
Los Angeles	167	85.10	72.40	-14.9
Merced	293	59.40	51.70	-15.0

* $P < 0.05$

In both counties, the results showed significant improvements in money saved on food purchases and in consumption of fruit and dairy products, and decreases in the consumption of nonnutritious foods (tables 3 and 4).

In urban Los Angeles County, the amount of money spent on food decreased by 14.9% ($P < 0.05$). In these same participants, fruit consumption increased by 0.4 servings and "other" foods (a measure of the consumption of nonnutritious foods) decreased by 0.4 servings. Both these behavior changes

were significant ($P < 0.05$). Other dietary changes were not significant.

In primarily rural Merced County, the amount of money spent on food decreased by 15% ($P < 0.05$). In these same participants, dairy product consumption (a measure of calcium intake) increased by 0.2 servings ($P < 0.05$). Other dietary changes were not significant.

Future programming

These dietary and economic food practices and food-safety results are presented annually to all FSNEP staff for two purposes: to identify the nutritional needs of FSNEP clients and provide feedback on staff teaching results. FSNEP staff use a variety of teaching methods to motivate clients to change their behavior. For example, telling participants that hand-washing is important does not make the point as well as the "glitter gel" demonstration, which shows that "germs" can rapidly spread among people and food. In this exercise, one participant rubs a little gel on his or her hand. After a short time participating in another activity, all participants can see the glitter on everything and everyone else. This type of teaching has a dramatic impact on participants who now clearly want to wash their hands.

FSNEP offers a variety of simple ideas to help families prepare easy, quick, low-cost and nutritious meals. Results from a study on the food-preparation practices of low-income families showed that these families lack cooking skills yet are interested in learning how to prepare nutritious meals for their families (West 1999; Joy et al. 1999). Currently, the "learner-centered" educational approach is being used in FSNEP to make sure that the needs of the clients are at the center of the educational program.

The evaluation results have helped the program staff to better understand the needs of the target audience. We

want to assist our clients to improve their diets for two reasons: first, by helping them to understand the importance of a healthy diet to reduce their risk of chronic disease, and second by convincing them that a healthy diet can be low-cost and delicious.

TABLE 4. Dietary changes in FSNEP clients, Los Angeles and Merced counties

County	Number	Pre-test*	Post-test	Change†
	 servings		
Los Angeles	167	1.1 (fruit)	1.5 (fruit)	+0.4
Los Angeles	167	1.4 (other)	1.0 (other)	-0.4
Merced‡	293	1.2 (dairy)	1.4 (dairy)	+0.2

* Servings were calculated by scoring the number of fruit, vegetable, dairy and "other" (high-fat, high-sugar) foods reported in 24-hour recalls before and after receiving nutrition education lessons.

† $P < 0.05$

‡ Used Home Study delivery method.

A.B. Joy is Academic Specialist, Department of Nutrition, UC Davis. Chris Hanson provided statewide data analysis, and William Benford provided demographic and individual county analysis. FSNEP county management was provided by Mary Blackburn, Gloria Espinoza-Hall, Nancy Feldman, Mary Fujii, Chutima Ganthavorn, Linda Garcia, Jan Harwood, Sharon Junge, Cathi Lamp, Martha Lopez, Anna Martin, Diane Metz, Yvonne Nicholson, Carol Powell, Jeanette Sutherlin, Patti Wooten Swanson, Barbara Turner, Estella West and Martha Weston. Beverly Benford provided administrative coordination. Funding for this study was provided by the U.S. Department of Agriculture through the California Department of Social Services.

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Photos: Suzanne Paisley



Nutrition education assistants provide lessons on nutrition, food safety and food preparation as part of the Food Stamp Nutrition Education Program, which serves about 50,000 people annually in California.

Animal Ambassadors . . .

4-H teens learn to lead science program for kids

Martin H. Smith
Richard P. Enfield
Cheryl L. Meehan
Donald J. Klingborg

To improve science literacy among school-age children in the United States, educators must receive effective training and support, and children must be engaged in science at a young age. Animal Ambassadors is a science-education outreach program of the UC School of Veterinary Medicine, Veterinary Medicine Extension, which focuses on the awareness and understanding of animal-related concepts and emphasizes important critical thinking and life skills. Through a collaboration with UC Cooperative Extension's San Luis Obispo County Youth Development Program, an Animal Ambassadors research project showed positive outcomes relative to interrelated goals involving teen training and youth science literacy.

Science literacy among school-age children is a state and national concern. Results from the Third International Math and Science Study (TIMSS) showed that science literacy among U.S. high school seniors is among the worst in the developed world (Hiraoka 1998). The 1999 TIMSS-Repeat, a follow-up test designed to monitor trends, indicated that performance in science by younger children in the United States was declining (TIMSS 1999; NCES 2000). Furthermore, in 2000, 4th- and 8th-grade students in California scored last on a nationwide science test (O'Sullivan et al. 2002).

In order to develop a scientifically literate population, it is crucial to engage children in science activities at an early age (Rubin 2002). Most educators who work with young children do not feel qualified to teach science (Fulp 2002), and



A program of the UC Davis Veterinary Medicine Extension, Animal Ambassadors seeks to stimulate interest in science through hands-on activities. Children from the San Luis Obispo County YMCA display their artwork from an Animal Ambassadors curriculum activity.

science teaching at the elementary-school level is regarded as the weak link in science education (Dana et al. 1997). In order to improve their teaching skills, teachers who work with this age group must receive effective training and support.

Animal Ambassadors

Animal Ambassadors is a youth science-education outreach program of the UC School of Veterinary Medicine, Veterinary Medicine Extension, at UC Davis. Initiated in 1999, the program aligns with California science-content standards and is designed to stimulate an interest in science through the use of a hands-on curriculum that emphasizes the Scientific Thinking Processes (observing, communicating, comparing, organizing, relating, inferring and applying) (Lowery 1992) and life skills (such as communication, teamwork, problem-solving and record-keeping) (Hendricks 1998). The curriculum activities use inquiry methods that

emphasize having children discover knowledge through their own exploration. Furthermore, the Animal Ambassadors curriculum is made interactive through the use of hands-on alternatives to live animals (such as rubber foot molds, plaster tooth casts and imitation animal coats) that are organized into learning kits. The activities are developmentally appropriate and organized around five major concepts: animal habitats and geography, structure and function, dietary needs and habits, animal communication, and human-animal interactions (Smith and students 2002).

In 1999 and 2000, the 4-H Youth Development Program in San Luis Obispo County received funding for a collaborative research project involving the Animal Ambassadors program, entitled "Animal Ambassadors – A Science Education Outreach Model." The project was structured around two interrelated goals: to develop a state and national training model for implementation and

It is crucial to engage children in science activities at an early age; but most educators who work with young children do not feel qualified to teach science.



4-H teen teachers from San Luis Obispo County prepare to practice the "World of Art" activity during an Animal Ambassadors curriculum-training workshop.



Andrea Laubscher, a 4-H program representative from San Luis Obispo County 4-H, works with 4-H teen teachers.

dissemination of the Animal Ambassadors science-education program, and to increase the science literacy of youth ages 5 to 8.

As the key component to state and national dissemination and implementation, project leaders designed and tested a "Step-Up" Incremental Training Model. A series of three workshops alternated with curriculum implementations that emphasized progressive skills development, such as understanding and using inquiry, effective questioning strategies, age-appropriate language and small-group instruction (Smith and Enfield 2002). Through increased skills, practice and instruction, the sequenced trainings are designed to progressively increase the competencies of the program's teachers over an extended period of time. This model was designed using 4-H teens, but has also been tested and shown effective with adult volunteer leaders (Smith et al. in press).

Implementation by 4-H volunteers

In the Animal Ambassadors model project, teens were used as cross-age teachers of younger youth, a common practice in 4-H youth development programs (Lee and Murdock 2001). In San Luis Obispo County, a call for volunteers went out to 4-H teen members via the 4-H monthly newsletter and direct recruitment letters, and indirectly through letters to 4-H community club leaders asking for their assistance in identifying

teens interested in participating in this project. Twenty-four teens from three clubs (Cerro Alto, Shandon and Parkfield) in different geographic locations were recruited; 15 teens completed the project. Attrition was due principally to transportation issues; some teens had to travel more than 90 minutes each way to participate in the curriculum trainings. The 15 teens that completed the project attended all trainings and curriculum implementations, and all data used in the analyses is from this cohort.

The San Luis Obispo County 4-H teens attended three curriculum-training workshops at the UC Cooperative Extension San Luis Obispo County office over a 3-month period beginning in early February and ending in late April 2000. Training workshops focused on introducing teens to the fundamentals of inquiry-based learning, and workshop facilitators modeled activities to reinforce effective methodology. Teens practiced the Animal Ambassadors curriculum in front of their peers in advance of implementation with young children, and significant time was allotted during trainings for reflection and review.

Working in teams, the teen teachers implemented the Animal Ambassadors curriculum activities during 14 sessions with primary 4-H members and young children of similar ages at two YMCA programs (Los Ranchos and Pacheco Day Camp). Implementation spanned either 7 or 14 weeks, depending on

whether the curriculum activities were scheduled on a weekly or bi-weekly basis.

Evaluating outcomes

During teen curriculum-training workshops, an emphasis was placed on effective questioning strategies. Understanding the difference between closed and open-ended questions, and applying this knowledge during instruction, is important to the successful implementation of inquiry-based activities. Closed questions typically have only one correct answer (such as, What type of teeth do animals use to grind food?) — the recitation of a fact — and are poor indicators of a student's true understanding of a concept (Latham 1997). Conversely, open-ended questions do not necessarily have right or wrong answers (such as, What do you know or wonder about different types of animal teeth?); rather, they encourage students to explore possible answers or solutions to problems or situations through group interactions and independent thought (Ciardiello 1998). Learning environments where educators practice the use of open-ended questioning promote the value of multiple ideas and perspectives and find students becoming more responsible for their own learning by generating their own questions (Martens 1999).

Multiple assessment measures were used to determine change in the teens' understanding and use of question-



4-H teen teachers, adult volunteer leaders and 4-H county staff work in teams during an Animal Ambassadors curriculum-training workshop.



Ashley Rademacher (left) and Nakia Wheeler (right), 4-H teen teachers from San Luis Obispo County, practice effective questioning strategies under the helpful eye of Jim Dewing, a 4-H adult volunteer leader.

ing strategies. Direct observations of curriculum implementations allowed researchers to compare the numbers of open and closed questions. A chi-square analysis of the data over the course of the three trainings revealed that the amount of training teens received did have a significant relationship with the types of questions they used during curriculum implementations (chi-square = 23.5, $P = 0.001$, $df = 2$; fig. 1). Furthermore, when asked during the focus-group interview how their participation in this project affected their approach to asking questions, the teens reported using more open-ended questions in numerous everyday situations.

Science skills in children

Program evaluators were looking for changes in the type and quality of the children's descriptions using the Scientific Thinking Processes. Changes were

measured using a performance-based "object description" assessment tool designed for this study. Children were given and asked to verbally describe two different objects (pre- and post-test) that were independent of the curriculum content. An audiotape of each description was made, and data were scored using written transcriptions of the audiotapes.

A total of 61 children participated in the Animal Ambassadors curriculum implementation over the course of the project. Because participation was voluntary and not every child was present when the pre- and post-intervention data was collected, data from 19 pre-/post- matched sets (eight boys; 11 girls) of children was analyzed. Data was quantified using a scoring rubric that measured the types of Scientific Thinking Processes and the manner in which they were used. The scoring rubric was: no observations or inferences made when describing the object, score = 0; observations made but no inferences, score = 1; observations and inferences made but inferences not based on observations, score = 2; and observations and inferences made and inferences based on observations, score = 3. A repeated-measures ANOVA was used to assess change in scores from pre- and post-test administrations of the object description tool. Results showed a significant improvement in Scientific Thinking Process score from pre-test (mean score = 1.55, standard deviation [SD] = 0.74) to post-test (mean score = 2.03, SD = 1.05) administrations ($F_{(1,35)} = 6.07$, $P = 0.025$).

Implications and recommendations

Effective training. The goals of the Animal Ambassadors — A Science Education Outreach Model project were interrelated. In order to have an impact on the target audience, it was essential that the training program for teen teachers be grounded in curriculum content and inquiry methodology. To accomplish this effectively, the curriculum trainings were planned in increments and delivered over an extended period of time. Loucks-Horsley et al. (1998) support this approach, stating that in-service training "confined to short, discrete events is a wasted effort." Additionally, Loucks-Horsley et al. maintain that effective in-service trainings require the participants to have direct experience in the learning they want their audience to encounter, and that this requires time, reflection and open communication with colleagues. The "Step-Up" Incremental Training Model meets these requirements. Over the course of the three-training sequence, 4-H teen leaders gained the competence and confidence necessary to become effective facilitators of the Animal Ambassadors curriculum.

4-H leaders as cross-age teachers.

Consistent with other studies involving 4-H teens as cross-age teachers of younger children (Ponzio et al. 2000), the teen leaders were effective in reaching their target audience and derived positive benefits themselves through their participation. To help facilitate the teens' success in their roles as cross-age

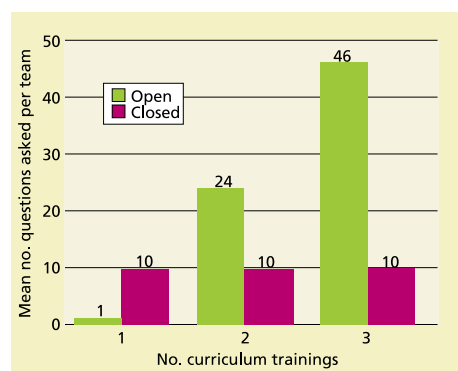


Fig. 1. Change in the types of questions asked by teen teaching teams (four teams at each time point) during the curriculum implementations following the three trainings.



4-H teen teachers and adult volunteer leaders who completed the Animal Ambassadors training and implementation project in San Luis Obispo County display their diplomas.

science teachers, as well as their learning and growth over the course of the project, they received full and continued support. County and campus-based academic personnel and 4-H adult volunteer leaders were responsible for overall project organization and logistics, which allowed the teens to concentrate on their role of implementing the curriculum with young children. Ponzio et al. (2000) note that this helps make teens more effective as cross-age teachers by allowing them to concentrate and focus on their instruction.

Encouraging inquiry

Most science taught in the United States is done using didactic methods — lectures and presentations — that do not promote exploration or independent thought (Jorgenson and Vanosdall 2002). However, according to Marlene Thier (Teacher Education Coordinator, Science Education for Public Understanding Program, Lawrence Hall of Science, Berkeley, personal communication, Nov. 21, 2002), the goal of science literacy is to “have students become independent learners.” The hands-on, inquiry-based approach to science education arouses children’s curiosity and holds their interest (Hinman 1999). It allows children the opportunity to construct knowledge through their own exploration and helps them to seek new information and understanding by becoming independent learners and thinkers (Richetti and Sheerin 1999).

UC has been called upon to help develop a scientifically literate population

that can be successful in the modern world (Price and Cardullo 2000). If the goal of science literacy — developing independent learners — is to be achieved, inquiry-based instruction and programs such as Animal Ambassadors will need to become more prevalent. Furthermore, in order to prepare those who teach science to use inquiry and use it effectively, it is important that they receive training and support that occurs over an extended period of time and in a manner that builds capacity through improved competence and confidence.

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Low-toxicity baits control ants in citrus orchards and grape vineyards

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Effective ant control is critical for controlling honeydew-secreting homopteran agricultural pests such as whitefly and mealybug. Low-toxicity ant baits may more effectively control ants than the broad-spectrum insecticides currently used in California vineyards and citrus orchards. This study focused on developing effective ant baits for use in bait stations to control field ant and Argentine ant, which aggressively tend homopteran pests. In the Coachella Valley, field ant is associated with the vine mealybug, a destructive nonnative pest. We conducted preference experiments for various commercially available ant baits and a bait formulated with anchovy plus imidacloprid. Field ant preferred the anchovy baits above all others tested, and in field trials the anchovy bait with 0.005% imidacloprid significantly reduced foraging activity. Argentine ant is the primary ant pest in vineyards and citrus orchards of California's nondesert growing regions. We tested the efficacy of several chemical bait treatments, all of which significantly lowered Argentine ant populations.

Biological control programs aimed at suppressing honeydew-secreting pests on citrus and grape must include ant control in order to optimize the effectiveness of natural enemies. Honeydew provides a stable food source for several species of ants (Beattie 1985). To protect this food source, ants will disturb or kill predators and parasitoids (Gullan 1997).



Field ants tend a vine mealybug colony, which is infesting the current season's girdling wound.

Citrus is often attacked by honeydew-producing homopterans such as soft scale (*Coccus hesperidum* L.), citrus mealybug (*Planococcus citri* Risso) and woolly whitefly (*Aleurothrixus floccosus* [Maskell]). Moreno et al. (1987) showed that the natural enemies of these pests provided more effective control when the Argentine ant (*Linepithema humile* [Mayr]) was absent. Itioka and Inoue (1996) demonstrated that ladybird beetles (Coccinellidae) and green lacewings (Chrysopidae) reduced a population of the mealybug (*Pseudococcus citriculus* Green) on Satsuma orange by 94% when the ant (*Lasius niger* L.) was controlled.

In California, three mealybug species — grape mealybug (*Pseudococcus maritimus* [Ehrhorn]), longtailed mealybug (*Pseudococcus longispinus* [Targioni-Tozzetti]) and obscure mealybug (*Pseudococcus viburni* Maskell) — commonly attack table, raisin and wine grape varieties. Predators such as lady beetles (*Cryptolaemus* sp.) and lacewings attack each of these species, and up to five species of parasitoids are known to attack the grape and longtailed mealybugs. In addition, the vine mealybug (*Planococcus*

ficus [Signoret]) is a recent arrival into California, first reported on table grapes in the Coachella Valley (Riverside County) in 1994. Since its arrival, the vine mealybug has been reported on raisin and table grapes in the San Joaquin Valley and on wine grapes in Santa Barbara, San Luis Obispo, Sonoma and Napa counties, for a total of about 30,000 acres statewide. Although little research has been conducted on the interaction between ants and the natural enemies of these mealybugs on grape, ant suppression is thought to play a critical role in their control.

In the Coachella Valley, the field ant (*Formica perpilosa* [Wheeler]) is the predominant ant species associated with vine mealybug. The acrobat ant (*Crematogaster* sp.) is also present but to a lesser extent. Two fire ants, the southern fire ant (*Solenopsis xyloni* [Wheeler]) and the thief ant (*Solenopsis molesta* [Say]), are also found; however, their interaction with vine mealybug is not fully understood. The native gray ant (*Formica aerata* [Francoeur]) is similar to the field ant and is the primary ant associated with vine mealybug in the San Joaquin



A choice-test arena (without lid) is used to determine the bait preferences of field ants.

Valley and San Luis Obispo County. The Argentine ant, as well as being a primary ant pest in citrus orchards of the coastal growing regions, is also the primary ant pest associated with vine mealybug in the wine vineyards of Sonoma and Napa counties.

Limitations of ant control methods

Current strategies to control ants in orchards generally include the application of residual insecticides, such as chlorpyrifos. Chlorpyrifos applied to the trunk and ground beneath a citrus tree provides a repellent barrier and kills foraging workers that come into contact with the insecticide. However, only limited control can be achieved because the queen or queens and the vast majority of workers in the nest are not affected. The effectiveness of chlorpyrifos is also limited by high temperature, irrigation and ground cover (Rust et al. 2000). When using this method, citrus trees must be skirt-pruned in order to prevent the ants from using alternative routes into the canopy. Trunk banding with an insecticide-impregnated paper or a sticky material is an effective method to prevent ants from foraging in the canopy. However, trunk banding is labor intensive and has not been adopted by the majority of growers.

Chlorpyrifos is also the primary method to control ants in vineyards, with similar limitations. Modifications to application techniques, which concentrate the spray to where the ants are located, have improved its effectiveness. Phillips and Sherk (1991)

improved the efficacy of chlorpyrifos to approximately 8 weeks by using a hand-held, compressed-air sprayer and concentrating the application to the trunk and trunk-soil interface. Klotz et al. (2003) improved on this approach and designed a spray rig mounted on an all-terrain vehicle, which delivered the insecticide to a 2-foot-wide strip of soil beneath the grapevines where field ant nests. This method provided control of field ant for approximately 9 weeks.

Development of baits and stations

Toxic baits may offer a more effective method for controlling ants in orchards and vineyards. The recruitment and food-sharing behavior of ants can be exploited in order to spread a toxicant through the colony. Ant baits generally contain three components — a matrix or carrier, feeding stimulant and toxicant. Each of these components plays a critical role in the bait's attractiveness, which makes developing an effective ant bait challenging. For example, the particle size of the carrier affects the rate of collection (Hooper-Bui and Rust 2000); typically, larger ants prefer a large particle size. The optimal percentages of carbohydrate, protein and fat in the feeding stimulant may vary according to the species of ant or the nutritional requirements of a colony. Also, the toxicant must not deter feeding and must be

slow acting so as not to impede recruitment and food sharing (Rust et al. 2000).

Bait delivered in stations minimizes environmental exposure to the toxicant, but developing an effective and economically feasible bait station also presents a challenge. The biology of the ant and its foraging behavior must be understood when considering the volume of bait that a station should contain and the number of stations needed per acre. For example, population densities of Argentine ant can be quite large. Markin (1967) conducted experiments in a citrus orchard in San Diego County and estimated that between 50,000 and 600,000 Argentine ants could ascend an individual citrus tree in a single day. Also, Argentine ants do not act aggressively toward nearby nests. Instead, they form a cooperative network of colonies throughout an area that represent one giant "supercolony." The biology and foraging behavior of field ants are in sharp contrast to that of the Argentine ant; field ants do not form large colonies and are territorial. We are in the initial stages of bait development and have made progress in finding preferred feeding stimulants and toxicants for field ant and Argentine ant.

Field ant baits and efficacy

Bait tests. Under field conditions, we tested five commercially available baits to control field ant: 1.0% hydramethylnon (Maxforce, Maxforce Insect Control Systems, Oakland, Calif.), 1.0% hydramethylnon (Maxforce, fine granular), 0.5% pyriproxyfen (Esteem, Valent U.S.A., Walnut Creek, Calif.), 5.0% orthoboric acid (Niban, Rockford, Tenn.) and 0.5% pyriproxyfen (Combat, Combat Insect Control, Pleasanton, Calif.). In addition, we tested a granular bait formulated with anchovy and 20–30 mesh corn grit developed in the laboratory of Dr. Michael Rust. The anchovy bait was tested with 0.005% and 0.05% imidacloprid.

These active ingredients generally have lower acute toxicity (LD_{50}) than

Low-toxicity ant baits are more effective than broad-spectrum insecticides because a bait is shared among nest mates and the queens.

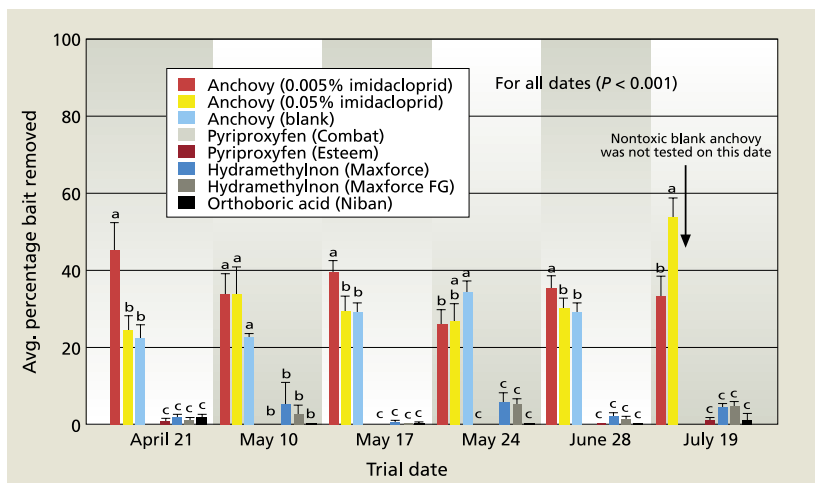


Fig. 1. Mean percentage bait removed (\pm SEM) by field ant in choice-test arenas placed at the base of ant-infested grapevines ($n = 10$). Ants were allowed to forage freely for 24 hours. On May 24, pyriproxyfen (Combat) replaced pyriproxyfen (Esteem) in each of the choice-test arenas.

commonly used broad-spectrum organophosphate insecticides. However, what makes these “low-toxicity” baits is their dose. The anchovy bait formulated with imidacloprid is unique; the authors are not aware of any such ant baits on the market.

The bait preference test was a completely randomized design conducted in a 20-acre block of ‘Superior Seedless’ grapes. A visual inspection of the vineyard indicated that it was heavily infested with field ants. Approximately 6 grams of each bait was placed in a 25-milliliter (ml.) plastic vial and then randomly assigned to a position in a choice-test arena. The arenas were constructed from aluminum pans (12 inches in diameter by 2 inches deep) with four equidistantly spaced holes located on the side of the pan flush with the bottom. Glass tubing (3/8 inch inside diameter and about 4 inches long) was inserted into each hole, so that ants entering the arena would emerge from the glass tubing at the center. Twelve small weigh boats (1-inch-by-1-inch-by-0.5-inch plastic dishes used to weigh powder and liquid compounds) were glued to the floor of the pan equidistantly spaced from one another along the inside perimeter. The weigh boats were modified so that the vials could be laid flat within them and locked in place. In the field, each arena was covered with a piece of plywood to protect it from direct sunlight and disturbance.

Ten choice-test arenas were placed in the vineyard for each of six trials, which were conducted on different dates. During each trial, arenas were

placed at the base of vines near ant nests, separated from one another by at least 80 feet within a vine row and 24 feet between vine rows to ensure that only one colony fed from each. Nests were exposed to baits only once during the experiment. Ants were allowed to forage freely in the arenas for 24 hours. The arenas were then collected, and the average percentage of each bait removed was calculated. The percentage of a test bait removed from a single arena was calculated as the number of grams of a single bait removed divided by the total number of grams of all baits removed. Data were arcsine square-root transformed and analyzed using analysis of variance and least significant difference to separate means within SAS.

On each of the test dates, the anchovy baits were removed from the test arenas in significantly greater amounts than all other baits (fig. 1). The average percentage removed of the two baits with anchovy plus imidacloprid varied slightly between test dates, but the differences were not consistent across test dates. This indicates that imidacloprid at the concentrations tested did not deter collection by the ants. During this experiment, field ant was observed foraging on Maxforce but at a very low rate.

Efficacy trial. We wanted to measure the short- and long-term impact of the most effective treatments for controlling field ant populations, as indicated by later foraging activity. In the efficacy trial, we tested both concentrations of imidacloprid (0.005% and 0.05%) in anchovy, Maxforce and a nontreated

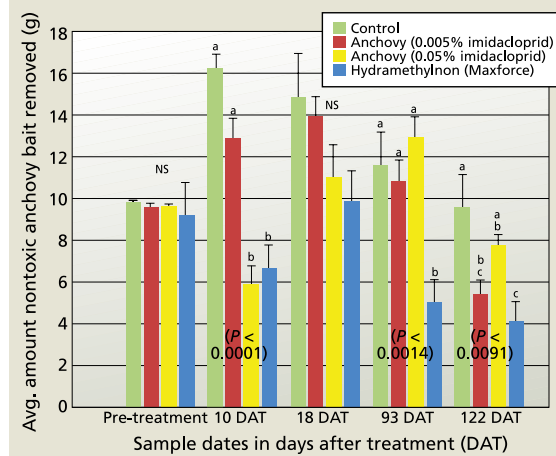


Fig. 2. On each sample date, population densities before and after a single insecticide treatment were monitored by allowing field ant to forage on about 20 grams of anchovy bait (nontoxic blank) placed at the base of four grapevines per plot and calculating the amount removed after 24 hours.

control. The experimental design was a completely randomized block, with four treatments replicated five times. Plots equaled about 0.04 acres and each consisted of 16 vines. In each plot, each of the 16 vines was treated with either concentration of imidacloprid in 20 grams of anchovy or 1 gram of Maxforce in a 90 ml. plastic vial placed and left at the base of the vine.

Pre- and post-treatment foraging activity of field ant were monitored using 20 grams of blank anchovy bait (no toxicant) in 90 ml. plastic vials placed at the base of the four central vines within each plot. After 24 hours, the vials were collected and returned to the laboratory, and the average amount of bait removed was calculated. Monitoring was conducted 2 days before treatment, and 10, 18, 93 and 122 days after treatment (DAT).

At 10 DAT, foraging activity of field ant significantly decreased in plots treated with Maxforce and anchovy plus 0.05% imidacloprid, but the foraging activity returned to the pre-treatment level by 18 DAT (fig. 2). Maxforce significantly reduced foraging activity below that of the control at 93 and 122 DAT. At 122 DAT, both anchovy baits reduced the foraging activity similarly, however only the lower rate of imidacloprid (0.005%) reduced the foraging activity significantly lower than the control.

Foraging activity. The process by which ants share food may explain these results. Larval stages, especially the later instars, are the only members of a colony that can feed on solid foods. Foragers bring solid food into the nest

and place it on the mouthparts of the larva; the food is then chewed and digested. The larval stage uses much of the nutritional value for growth, but excess soluble proteins and amino acids can be stored (often in the salivary glands) and then later secreted to workers as a liquid food (Abbot 1978).

The decrease in foraging activity observed at 10 DAT suggests that the workers that foraged and processed the Maxforce or anchovy plus 0.05% imidacloprid baits suffered significant mortality; the rebound occurred as a result of the dead workers being replaced by workers from within the nest. The more delayed reduction in foraging activity observed at 93 DAT (Maxforce) and 122 DAT (Maxforce and anchovy plus 0.005% imidacloprid) strongly suggests that these baits affected significant mortality among the brood and reduced the colony size.

Developing bait stations

We are encouraged by these results. In subsequent experiments, we will vary both the percentage of imidacloprid in the anchovy bait and the application rate to determine if we can improve its efficacy. The advantage of formulating anchovy bait with imidacloprid is that imidacloprid is currently registered for use on grape as both a foliar and systemic insecticide. We believe that a bait such as this would quickly be approved for use against field ant as a broadcast bait, thereby eliminating the need for bait stations. The reduction in foraging activity in the plots treated with Maxforce suggests that hydramethylnon is also an effective toxicant. Experiments conducted in the spring and summer 2004 included various rates of hydramethylnon formulated in the anchovy bait.

An advantage to the commercial ant baits is their availability once registration is complete. Our data indicates that Maxforce with 1.0% hydramethylnon is also a candidate for such registration, although we have not yet developed a cost-effective bait station to deliver it. Densities of field ant can be high, with approximately 50 nests per acre. Our goal is to develop a disposable bait sta-

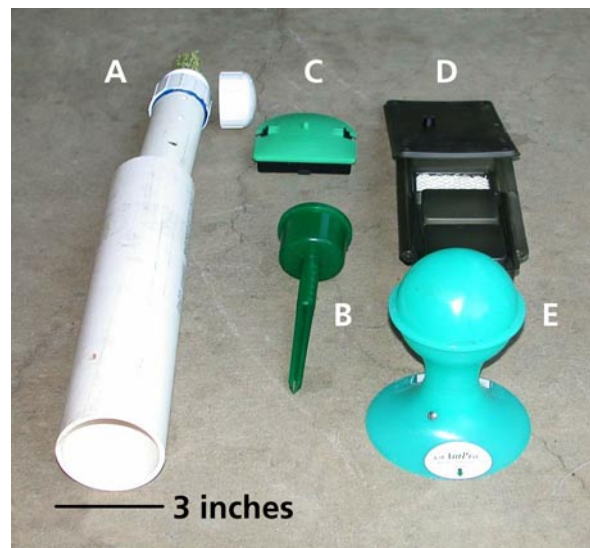
tion that can be filled with an appropriate bait, such as anchovy or Maxforce, and placed near the entrance of each nest.

At this stage in our research, we do not fully understand how populations of other ant species — such as acrobat ant and the two species of fire ants — will respond in the absence of field ant. At no time during the preference trial did we observe acrobat ant foraging in the test arenas. However, the fire ants (*S. molesta* and *S. xyloni*) foraged Combat, and *S. molesta* also collected Niban. These baits may also be candidates for registration in bait stations if the population of any of these species were to increase to pest status in the absence of field ant.

Argentine ant baits and efficacy

In previous research, Rust et al. (2000) designed the choice-test arena described above in order to determine food preferences of Argentine ant. They found that both 20% sucrose water and Maxforce granular (nontoxic blank) were highly preferred and consistently collected by Argentine ant year-round. Rust et al. (2000) also determined the effective concentration range of several toxicants in sucrose water for Argentine ant. On the basis of their research, we chose a liquid bait (25% sucrose water plus 0.0001% thiamethoxam) and Maxforce to test in citrus.

The baits were tested in a 40-acre Valencia orange orchard. The liquid bait, liquid-plus-solid baits and controls (nontreated) were randomly assigned to twelve 1.5-acre plots such that each treatment was replicated four times. Each plot consisted of a 9-by-12 block of trees. Plots were separated by seven rows of trees, which served as a buffer. Baits were placed in stations at the base of every fourth tree in a plot along the irrigation line, providing an equivalent of 22 stations per acre.



Ant bait stations submitted to the U.S. Environmental Protection Agency for use in citrus orchards and grape vineyards were: (A) liquid, constructed from PVC pipe — design used in trials to control Argentine ant on citrus; (B) granular (Kness Manufacturing Co., Albia, IA); (C) granular, B&G Perimeter Patrol System (B&G Equipment Co., Plumsteadville, PA); (D) liquid, used to control Argentine ant in citrus (Whitmire Micro-Gen, St. Louis, MO); and (E) liquid, (Km AntPro, Nokomis, FL). All except (A) are commercially available.

Ant activity was estimated in each plot twice monthly using 50 ml. monitoring tubes constructed according to specifications described by Klotz et al. (2003). Tubes were filled with 25% sucrose water, weighed and taped to the trunk of each of nine trees located in a three-by-three configuration at the center of each plot. Two additional control tubes were hung in two of the central trees to measure evaporation. To prevent ants from foraging on the control tubes, they were suspended from string coated with Stickem Special (Seabright, Emeryville, Calif.). Ants were allowed to feed from the monitoring tubes for 24 hours. The monitoring and control tubes were then collected and reweighed to calculate weight loss. The evaporative water loss from control tubes was determined and used to calculate the net consumption from each monitoring tube, which provided us with an estimate of the activity of ants in each plot. During the 24-hour monitoring period, the toxic bait stations were temporarily sealed with plastic bags to prevent competition with the monitoring tubes.

Data was pooled across observation dates and analyzed using the Kruskal-Wallis nonparametric procedure (Systat version 9) to test for a treatment ef-

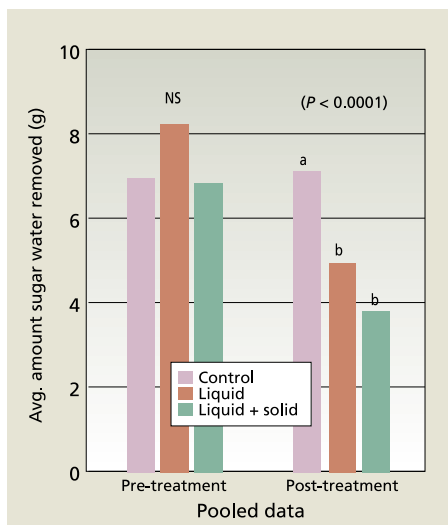


Fig. 3. Mean grams of sucrose water removed from monitoring tubes. Data was pooled across observation dates. Monitoring tubes were placed on citrus tree trunks and Argentine ants were allowed to feed for 24 hours. Means with the same letter are not significantly different.

fect, and the Nemenyi procedure was used to test for differences among the treatments. During the pre-treatment observation period (May 14 through July 1), consumption of sucrose water did not differ significantly among the experimental plots ($P = 0.99925$). Post-treatment consumption of sucrose water, however, did differ among the plots ($P < 0.0001$). The plots treated with the liquid and liquid-plus-solid baits had less consumption of sugar water than the control, but did not significantly differ from one another (fig. 3).

Registration considerations

All pesticide formulations must be registered on a crop before they can be used legally to control a pest species, an essential consideration for taking control technologies from research and demonstration projects to production agriculture. To achieve registration, the agricultural chemical companies that handle the active ingredients must first agree to their use; their pesticides cannot be used without consent. Finally, the U.S. Environmental Protection Agency (EPA) must approve the registration, which normally requires data to be submitted. These data requirements can be extensive, and agricultural chemical companies normally bear the expense.

The Interregional Research Project Number 4 (IR-4) was organized to facilitate pesticide registration in cases where economic incentives for the companies are lacking. Such registrations have been termed "minor use." For minor use, the costs of achieving registrations are normally more than the potential economic benefit to the companies. Ant baits for use in vineyards and orchards would be considered by most of the companies to be minor uses.

In cooperation with University of Hawaii and UC Riverside researchers, IR-4 has been working on ant baits in pineapple fields, vineyards and orchards. IR-4 negotiated with the EPA for concessions that will make it easier to register ant baits. In lieu of a broadcast application, ant baits will have to be delivered in bait stations placed in the pineapple field, orchard or vineyard, and the bait stations must prevent any potential contact of the pesticide with the harvestable crop. The degree of protection provided by the bait stations convinced EPA that certain expensive data requirements could be waived, making future registration of these innovative technologies much more likely.

Effective ant control

The management of ants that tend homopteran pests is a key component of integrated pest management in vineyards and citrus orchards. Low-toxicity ant baits are more effective than broad-spectrum insecticides because a bait is shared among nest mates and the queen(s). Additionally, ant baits are target-specific and when applied in stations, the risk to nontarget organisms and risk of environmental contamination is minimized.

Although we focused our study on developing baits to control ant pests in vineyards and citrus orchards, the methods we have developed to screen potential baits for feeding preference and test their efficacy under field conditions are applicable to other cropping systems. Our goal is to provide growers with cost-effective, easy-to-use bait delivery systems, and through collaboration with IR-4 to obtain registration of these products for use in agriculture.

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Weeds accurately mapped using DGPS and ground-based vision identification

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We describe a method for locating and identifying weeds, using cotton as the example crop. The system used a digital video camera for capturing images along the crop seedline while simultaneously capturing data from a global positioning system (GPS) receiver. Image time-stamps were synchronized with GPS time so that GPS coordinates could be overlaid onto selected images. The video system continuously mapped nutsedge weeds and crop plants within the seedline, allowing weed locations to be described with centimeter-scale accuracy when using a real-time kinematic GPS (RTK-GPS). This system may be used to develop maps of weed and crop populations as part of precision crop-management decisions.

Knowing where recurrent weeds or insect infestations occur over multiple growing seasons can facilitate the selective application of herbicides, pesticides and soil treatments. This information can be economically beneficial to growers because it allows areas at high risk for weed infestation to be treated prior to weed emergence while areas below an economic threshold can remain untreated. There is an ongoing need to reduce chemical applications, due to continued concern among regulators and economic constraints on growers. The methods described in this report are one step in that direction.

A large amount of research has been conducted on remote sensing with aerial and satellite imagery for yield and weed mapping in agriculture. GIS/ArcView/ArcInfo systems continue to be widely used for decision-making in precision agriculture and crop manage-

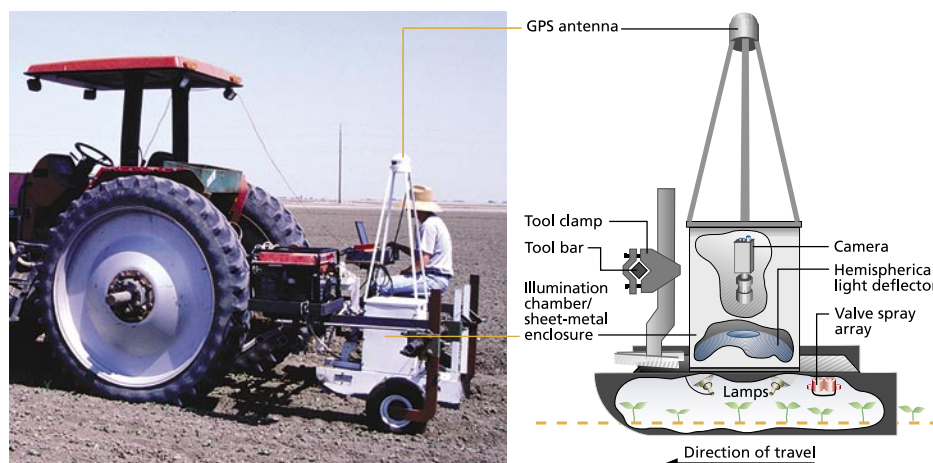


Fig. 1. Toolbar-mounted weed-mapping and location system. A tractor-mounted toolbar with a camera enclosure and GPS antenna were used to acquire images and location data.

ment. In-field vision detection (a nondestructive measurement) for site-specific crop management has a higher resolution ("centimeter scale" accuracy) than satellite or aerial imagery, which typically have 3.28-foot to 32.8-foot (1-meter to 10-meter) scale accuracy. In-field vision systems may also allow descriptions of weed species.

Discrete sampling has been the most common method to identify and map weeds but it is time consuming, and small grid sizes are not feasible for mapping large areas (Rew and Cousens 2001). Furthermore, quadrant size and sampling intensity are totally arbitrary, and large areas of the field can remain unsampled.

Manual surveys of weed locations in fields were described by Webster and Cardina (1997), who mapped and assessed accuracy in simulated weed patches of 16.4, 164.1 and 1,641 square feet (5, 50 and 500 square meters) using a backpack fitted with a global positioning system (GPS) receiver and antennae. Errors associated with area measurements were lowest with the 1,641-square-foot (500-square-meter) area (3% to 6%) and largest in the 16.4-square-foot (5-square-meter) area (14%

to 32%). The authors estimated that the 25 weed patches with the largest areas would require 21 minutes of continuous data collection (probably not including post-processing time for management decisions). Navigation assessments upon returning to previously mapped locations indicated that 27% of the original quadrants were found, and of those, 73% were found within 3 feet (1 meter) of the original location.

Van Wychen et al. (2002) discussed a continuous mapping system using an all-terrain vehicle mounted with a differential GPS receiver (DGPS), computer and human crop consultant. Maps were created by traversing the perimeter of patches, and transects across the field were driven every 30.2 feet (9.2 meters). The discrete method of developing a wild-oat seedling map entailed walking parallel transects in specified grid patterns and counting wild-oat density in 3.1-square-foot (0.29-square-meter) rectangular grids and georeference locations with a GPS receiver and computer. The results found that continuously sampled weed-seedling maps with weeds identified as present or absent were cost effective if the accuracy in locating patches was greater than 70%.

The system had an overall accuracy of about 85%, similar to the weed-control accuracy of a typical hand-hoeing crew.

Manh et al. (2001) indicated that weed identification continues to be difficult due to the complexity of ambient outside light and variability in plant morphology (form and structure). Their research described weed leaf segmentation (the identification of individual leaves) using deformable templates (a machine-vision technique where the leaf pattern or template is modified or deformed to match the unique shape of a specific leaf). The approach applied prior knowledge to the object searched and improved the weed segmentation stage. Although the study considered only one weed species, partially occluded (hidden) leaves were identified correctly. Additional work by Tang et al. (2001) described a sensor-based, high-resolution, real-time system for mapping in-field variability in weed load. Cameras were suspended (without shading) 10.5 feet (3.2 meters) above the soil surface, but results found that variability in outdoor lighting resulted in variations in camera performance.

Research at UC Davis developed a weed-control system for selective herbicide applications using machine vision (Lee et al. 1999). The system was towed by a tractor traveling 0.75 miles per hour (mph; 1.2 kilometers per hour) and was able to process images within 0.344 seconds. In field tests 24.2% of tomatoes were incorrectly categorized as weeds and sprayed, while 52.4% of weeds were not sprayed. Lamm et al. (2002) continued this work in cotton and developed a nonmorphological machine-vision technique that could discriminate between partially occluded narrow-leaf and broadleaf plants. The system identified and sprayed 88.8% of the weeds during in-row seedline image capture and analysis; these results are comparable to hand-hoeing, which eliminates only 65% to 85% of weeds.

The machine-vision systems described in the previous studies may be prohibitively expensive if used for large-scale weed mapping or in conjunction with robotic spraying. In a re-

cent study, Gliever and Slaughter (2001) developed a cost-effective method for successfully identifying and mapping weeds within crops. The software used an artificial neural network with a demonstrated accuracy of 92% for weed recognition.

Research on discriminating between weeds and crops under ambient light conditions continues to be a challenge. Recent work at UC Davis resulted in a mapping system that can be used to identify weed densities at specific geographic locations. The system links GPS coordinates to images of the crop seedline for future management analysis and decision-making. This type of mapping system can be a feature in current software used in precision agriculture. Automated GPS mapping of images linked to latitude and longitude is a new method for inspecting remote areas for weed and insect problems during the early stage of crop growth.

The objective of this study was to acquire GPS coordinates simultaneously with digital images of weeds in early-season cotton and to develop an automated routine to identify and map weed and crop densities for crop management.

Weed mapping in a cotton field

The crop rotation schedule in the test field prevented multiyear data collection for this study. Multiyear images of the same fields would allow for verification of returning or localized weed infestations. Although this was not possible, the system design and concept for future software use are still valid. Data from 2002 is used here to show proof of the concept.

The test site was on a commercial farm in the San Joaquin Valley, outside of Corcoran. Cotton was planted in April 2002. Images of early-season cotton were acquired approximately 10 days after planting. Yellow nutsedge (*Cyperus esculentus* L.) was the only weed species present in the test site. Two test plots (S3 and R14) were studied. The S3 test plot was 0.74 acre

(0.3 hectare) with approximately 280-foot (85-meter) row lengths and 18 rows on 3.3-foot (1-meter) spacings; the R14 test plot was 0.35 acre (0.14 hectare) with 150-foot (45-meter) row lengths and 17 rows on 3.3-foot (1-meter) spacings. Rows for both test plots were aligned on an ENE-WSW line. These plots were selected because these fields had a history of patchy weed populations with weed-free areas, as well as areas with a high percentage of weed cover.

The GPS antenna was located along the optical axis of the digital camera mounted on a tractor-drawn toolbar (Model DCR-TRV900, 3 CCD, Sony). The camera was set inside a sheet-metal enclosure that prevented sunlight from entering the image acquisition area, and diffuse artificial lighting was provided (Lamm et al. 2002). The camera viewed a 6-inch-by-4-inch region along the seedline and was equipped with removable digital videotape (miniDV format, 60-minute capacity). Continuous digital video of the seedline was collected in the camera's progressive scan mode to allow the full vertical resolution to be utilized while collecting images from a moving vehicle. Field location (latitude and longitude) and ground speed of the vehicle were monitored using a CASE AFS Universal Receiver (Model SB2400 with fast update option, DGPS U.S. Coast Guard beacon signal and NMEA-0183 data output strings) interfaced with a portable computer (Inspiron 3800/Celeron 500, Dell Computer) for GPS data storage. Data was captured from the GPS receiver at 10 Hz via an RS-232 serial line.

Video and coordinate data were simultaneously collected while traveling along the seedline of the crop at an average speed of 1.57 mph. GPS time was synchronized with the digital videotape time-code by filming GPS time on the receiver display at the beginning of each row. The NMEA-0183 GPS data string was post-processed; latitude and longitude were transformed to x , y and z metric coordinates using the coordinate conversion equations presented by Dana (1999) for distance traveled. The coordinate data was processed for each approximately 1.64 feet (0.5 meters) of forward travel and the corresponding

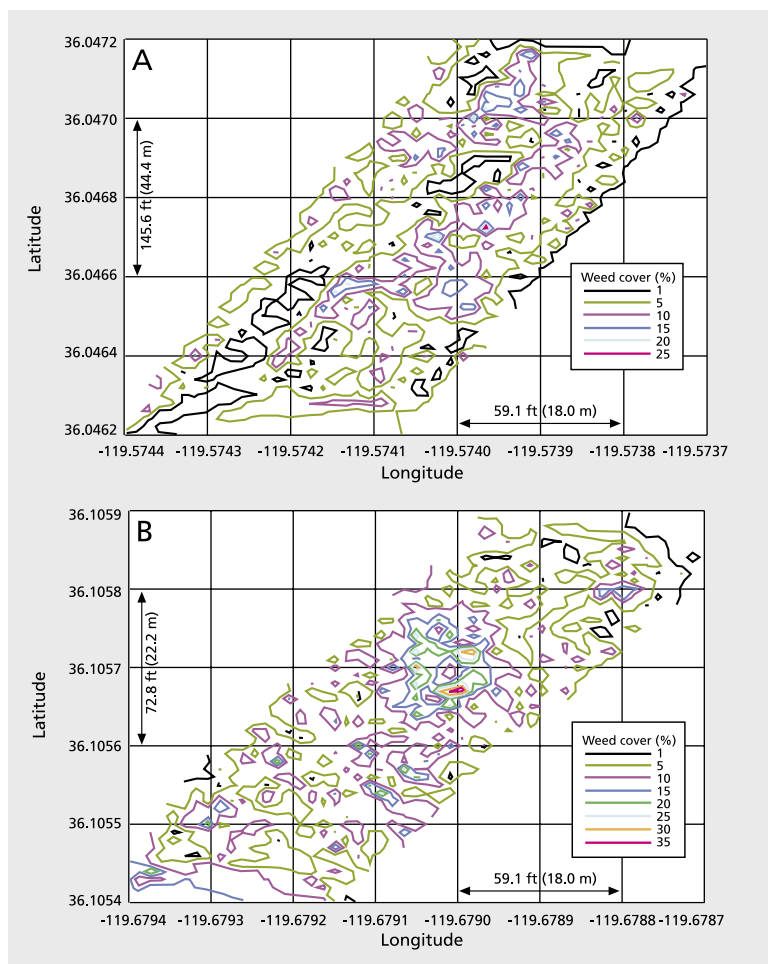


Fig. 2. Percentage weed-cover contour map of plots (A) S3 and (B) R14, developed by the automated location and identification process. Source: Downey et al. 2003.

time-stamps (from the NMEA-0183 data string) annotated for that travel distance. This data was used to overlay coordinates on each video frame representing 1.64 feet (0.5 meters) of forward travel. By counting through the frames based on GPS time downloaded from the GPS receiver, the video frame for each GPS coordinate could be identified.

Digital video was transferred from tape and stored in AVI digital video format on the computer hard disk using Adobe Premiere (v. 6, Adobe Systems) software and an IEEE-1394 communication line. A Visual C++ (v. 6.0, Microsoft) program was used to extract the video frame corresponding to each GPS coordinate and to label each image with its GPS coordinate. A total of 4,962 video frames (3,366 for S3 and 1,596 for R14) were extracted from the two test plots. An additional C++ program was used to automatically inspect each image for the presence of cotton and nutsedge plants using Gliever and Slaughter's (2001) method, in which the image is

subdivided into 128 grid cells, each corresponding to a 0.2-square-inch (1.2-square-centimeter) region of the seedline.

The percentage weed cover or cotton density at each GPS coordinate was defined as the percentage of grid cells containing nutsedge or cotton leaves, respectively, in the corresponding image. Cells that contained both cotton and nutsedge leaves were classified as cotton. Fifty video frames were randomly selected for manual validation of the accuracy of the image processing method. A percentage weed-cover or cotton-density contour map was produced for each plot using the contour procedure in commercial software (SAS/GRAPH, SAS Institute, 1999).

Weed map verification

The mean percentage of nutsedge cover, or number of grid cells in which nutsedge leaves occurred was 5.8% and 8.0% in the S3 and R14 plots, respectively, with standard deviations of 5.5% and

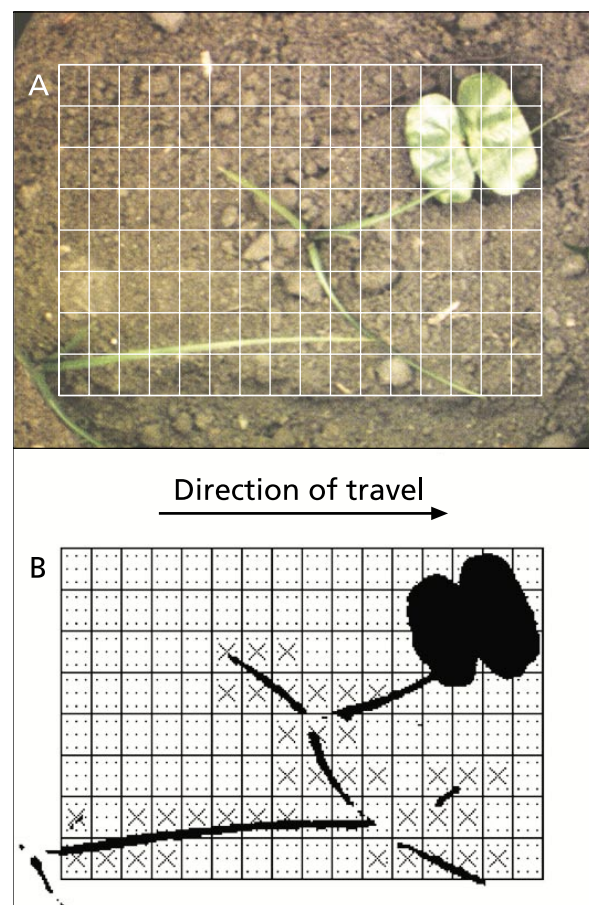


Fig. 3. (A) A cotton plant partially occluded by a nutsedge leaf; (B) weed map of (A) where grid cells containing nutsedge leaves are marked with an "X." Note: A thin piece of crop residue was mistakenly mapped as a weed due to an error in the color classifier. Source: Lamm 2000.

6.0% (fig. 2). These maps show the variability in percentage weed cover across the plots with patches of high weed densities observed toward the centers of both. The 4,962 images analyzed to produce these maps represent a total land area of 800 square feet (74.4 square meters) distributed over 1.64-foot (0.5 meter) intervals along the seedlines in 1.1 acre (0.44 hectare) of a commercial cotton farm.

Seventy-four percent of the 221 nutsedge leaves present in the 50 validation images were correctly identified. The primary causes of misclassification of nutsedge leaves (as cotton) were occlusion and the decision to classify grid cells containing both nutsedge and cotton as cotton (fig. 3). The original purpose of the weed-map algorithm developed by Gliever and Slaughter (2001) was to create a precision spray map. In this application, grid cells containing both cotton and weed leaves were mapped as cotton in order to avoid spraying the cotton plants. The



A weed scientist manually counts weeds inside a frame. Weed mapping using machine vision and a global positioning system is much faster and just as accurate.

secondary cause of misclassifying nutsedge as soil was the low resolution of sampling points (12 points per 0.2-square-inch [1.2-square-centimeter] grid cell) in the image, which caused small, thin leaves to be missed. These results are slightly lower than the weed recognition rate observed by Gliever and Slaughter (2001) or Lamm et al. (2002).

Ninety-two percent of the cotton leaves present in the 50 validation images were correctly identified. The primary cause for misclassifying cotton leaves as weeds or soil was brown tissue damage on the leaf. Brown spots on a leaf were classified as soil, and depending upon the quantity and size of the spots, the resulting visual pattern was frequently classified as a weed. These results are comparable to those observed by Gliever and Slaughter (2001) and better than those observed by Lamm et al. (2002). The overall accuracy of the system was about 85%, which was comparable to that observed by Lamm et al. (2002) and similar to the 65% to 85% accuracy of a typical hand-hoeing crew (Vargas et al. 1996).

When implemented on a computer with a 1.7 GHz processor (Intel Pentium 4), the weed-map algorithm developed by Gliever and Slaughter (2001) could map the weeds in a 320 x 240 pixel image at a rate of 10 frames per second. While the post-processing of the GPS data and the conversion of the digital video to a format accessible to the image processor required manual intervention, the creation of the weed maps themselves was completely automated. This represents a dramatic labor savings when compared to traditional methods of weed mapping. In addition, the manual tasks are primarily associated with the initial setup and are not dependent upon the number of images analyzed. An automated system of this

type can provide a significantly more detailed description of the percentage weed cover in a field. In this study, the images were sampled every 1.64 feet (0.5 meters) of seedline due to the accuracy of the DGPS system. However, the system is capable of analyzing every frame and making a continuous map of the entire field.

While this paper focused on weed mapping, the system could easily produce a map of crop density at the same time. The weed and crop maps could be utilized as layers in a GIS database and incorporated in a comprehensive assessment of crop yield, and to develop site-specific input application maps.

Mapping as accurate as hoeing

An automatic weed-mapping location and identification system was developed and tested in a commercial cotton field. The system used a video camera, image-processing system and DGPS data-logger to map nutsedge in cotton. The system had an overall accuracy of about 85%, similar to the weed-control accuracy of a typical hand-hoeing crew.

The system demonstrates the technical feasibility of automated weed-mapping. With a processing rate of 10 images per second, the potential for labor savings compared with conventional weed-mapping methods is significant. The technique could be combined with farming operations — including planting, cultivating or chemical applications (such as fertilization or insecticide sprays) — further reducing labor, fuel and equipment (such as tractor) costs. An automated, low-cost, weed mapping system would allow growers to track weeds throughout the season to provide feedback on the efficacy of weed management programs and in GPS yield map analysis. The authors acknowledge that the current economic cost of computer vision equipment and practical feasibility of using video cameras in ground-based agricultural field operations continues to be a challenge for future implementation. Also, future research is needed to expand the scope of weed identification algorithms,

for example to distinguish differences between broadleaf weeds and broadleaf crops, in addition to a wider range of weed species.

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Reviews are generally 3,500 words and analyze recent developments in research that significantly impact agricultural, natural or human resources in California. Readers should be able to learn what has been firmly established and what are unresolved questions or future directions for research. Reviews may discuss research developments in the context of public policy debates and identify priorities for research efforts

and funding. Reviews are documented by literature citations.

Perspectives appearing in the research section are review articles that interpret and analyze recent developments in research and public policy and express an opinion concerning the resulting impact on California's agricultural, natural and human resources.

New pests and diseases are shorter review articles describing new pests and diseases of statewide significance. They are generally 2,500 to 3,000 words. Authors are expected to describe the host range, geographic range and important biological characteristics of the pest, citing the relevant literature. Articles must contain California data, although it may be preliminary, and describe expected impacts of the pest in California.

Special issues or sections typically include both reviews and research articles on subjects that have stimulated significant research and/or extension efforts at UC, and which have interest for a wide cross-section of the audience. The editor or faculty guest editors solicit most articles for special issues, but suggestions for coverage are welcome. Both solicited and unsolicited articles undergo peer review. For special section guidelines please e-mail janet.white@ucop.edu.

Sidebars are published in the text of signed manuscripts and illustrate or offer expanded discussion of a single aspect of the accompanying article. They are typically 600 to 1,000 words. Because of the brevity of sidebars, conclusions drawn and assertions made must either be supported by the accompanying manuscript or by literature citations listed at the sidebar's conclusion. Like all signed papers, faculty-authored sidebars must undergo peer review, but they are evaluated for accuracy and balance rather than for formal presentation of scientific data.

News sections of the journal

All items in the news section at the front of the magazine are developed in-house, based on UC research and extension activity. Faculty sources review these items for accuracy and balance of presentation. However, they

are not peer-reviewed articles, nor do faculty authors sign them. They include Science briefs, Outreach news, Letters to the editor, Research updates and Progress reports. Suggestions for coverage are welcome.

Peer review

All manuscripts submitted for publication in *California Agriculture* must undergo anonymous peer review before they can be accepted. We have a double-blind review policy, in which neither authors nor reviewers are identified to each other. Associate Editors, who oversee review, are known to all parties. We forward each submission to the appropriate Associate Editor, who makes an initial determination of its (1) scientific soundness and (2) suitability for the *California Agriculture* audience.

The Associate Editor then nominates at least three qualified reviewers who are recognized leaders in the relevant disciplines. Reviewers are often from UC, but may also be appointed from other institutions and locations. If the first two reviews are affirmative, the article is accepted. If one is negative, we send the manuscript to a third reviewer. The Associate Editor, in consultation with the Executive Editor, makes the final decision on the disposition of the manuscript.

In the last 3 years, the rejection rate has run from 20% to 25%. Although most manuscripts make it through review, very few manuscripts get through review "clean." Associate Editors alone send back 7% to 10% for revision prior to peer review. As a rule, reviewers also require some revision before acceptance.

Audience

California Agriculture is edited to reach a diverse, well-educated audience. Based on a 2003 reader survey to which 66% of our subscribers responded, 33% work in agriculture (25% in production or processing, 8% in agribusiness), and 31% are either faculty members at universities or research scientists. One-fifth or 19% work in government agencies or are elected office-holders. Of respondents, 87% are college graduates and 55% hold advanced degrees.

Submitting the manuscript

Please use the checklist below to properly submit your manuscript to *California Agriculture*. You will receive an acknowledgment of receipt. With your permission, *California Agriculture* now sends manuscripts for peer review in electronic format. We will e-mail the manuscript to the appropriate Associate Editor, and based on his or her recommendations, will e-mail it to two reviewers.

After we hear from the reviewers (ideally within 3 weeks), we will send you their recommendations and comments, and the Associate Editor's instructions. If the manuscript has been accepted for publication, you will be asked to revise it in response to the reviewers' and Associate Editor's suggestions.

Once the Associate Editor accepts the revised manuscript, we will ask for the final version in electronic form. The author will receive edited galleys — usually with

numerous queries — for correction and approval before publication.

Illustrative material

California Agriculture prints high-quality color images with all articles, primarily using art supplied by the author. Digitized images, whether scanned from conventional prints or captured with a digital camera, must provide the resolution needed for our purposes. We prefer digital images at least 300 dpi at 4" × 6" and saved as a TIFF or high-resolution JPEG file. Or, you may submit 35 mm color slides, preferably good-quality originals. As a last resort, we can use good-quality color prints. We will return your slides or prints after publication.

For more information about submitting images to *California Agriculture*, contact Davis Krauter at (510) 987-0046 or davis.krauter@ucop.edu.

Matters of style

Refer to a recent issue and the full Writing Guidelines for matters of style. Below are some special requests and notes.

Abbreviations, symbols and acronyms. Abbreviations should be defined the first time they are used.

Chemical names. We prefer the common name, with trade name the first time in parentheses (no trademark symbol necessary).

Literature citations and references. *California Agriculture* publishes citations and references in the interests of good scholarship and proper factual documentation. We ask authors to limit their lists to key sources of documentation and to about 20 maximum. *California Agriculture* does not use footnotes.

Metrics. We publish results either in standard English measure or in English measure followed by metrics in parentheses.

Scientific names. It is appropriate to give the scientific name (with or without author) the first time mentioned, but avoid putting it in the headline or first sentence of the article. After the scientific name is given once, use the common name.

Checklist for submission

We prefer manuscripts and cover letters submitted via e-mail in Microsoft Word attachments to calagdesk@ucop.edu and janet.byron@ucop.edu. We will send a PDF version of the manuscript to the Associate Editor and peer reviewers.

If you do not agree to the electronic transfer of your manuscript, we will send out hard copies. If you prefer to submit by mail, send the cover letter and three copies of the manuscript to: Editor, *California Agriculture*, 1111 Franklin St., 6th Floor, Oakland, CA 94607-5200.

In preparing the manuscript, please:

- Double-space the whole manuscript, and include all tables, figures and captions.
- Use a 12-point font, such as Palatino or Times New Roman.
- Leave margins that are a minimum of 1 inch.
- Include line numbering (per page) and page numbers.
- Include figures and tables at the end of the manuscript; do not embed them in the text.
- Digital images or color slides may be submitted at this time or when the manuscript has been accepted for publication.

The cover letter should include:

- The names, addresses, e-mail addresses and telephone numbers of all authors.
- The headline (title) of the paper and a statement of its main point.
- The total number of words (including text, references, and figure and table legends) in the manuscript.
- A statement that the material has not been published and is not under consideration for publication elsewhere.
- A statement specifying when data was collected; and if the final data was collected more than 3 years before submission, why they are timely and relevant.
- A statement that you permit the electronic transfer of your manuscript to the peer reviewers and Associate Editor.
- A list of photographic illustrations, either available or suggested.



Calvin F. (Benny) Foutche

A ground-driven spray rig is used to treat a pear orchard in the Sacramento Delta with azinphos-methyl for codling moth control. Many such uses of broad-spectrum organophosphate insecticides have been or will be limited due to health and environmental concerns.

Visit *California Agriculture* on the Internet:

<http://CaliforniaAgriculture.ucop.edu>

Life after organophosphates

Insecticides have long been important tools for California farmers to combat agricultural pests. After World War II, organophosphate (OP) insecticides provided an inexpensive and effective mechanism for fighting a broad spectrum of damaging crop pests. However, they also raised critical health and environmental issues; as a result, many uses of OPs have been banned and further restrictions are likely under the Food Quality Protection Act (FQPA) of 1996. In the next issue of *California Agriculture*, scientists describe an array of important alternatives to OPs for fighting insect pests, including synthetic neonicotinoid and pyrethroid insecticides, new and novel pesticides, and nonchemical and biologically based approaches. If agriculture is to remain a dominant California industry, growers will need to understand and adopt these innovative techniques and pest-control products, authors say.

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