California
Water Resources Center

Annual Report
2000-2001

July 1, 2000 to June 30, 2001

Dr. John Letey, Director

University of California
Water Resources Center
Report No. 102

ISSN 0575-4968
May 2002

The University of California prohibits discrimination against or harassment of any person employed by or seeking employment with the University on the basis of race, color, national origin, religion, sex, physical or mental disability, medical condition (cancer-related), ancestry, marital status, sexual orientation, citizenship or status as a Vietnam-era veteran or special disabled veteran.

The University of California is an affirmative action/equal opportunity employer. The University undertakes affirmative action to ensure equal employment opportunity for underutilized minorities and women, for persons with disabilities and for Vietnam-era and special disabled veterans.

University policy is intended to be consistent with the provisions of applicable State and Federal law. Inquiries regarding this policy may be addressed to the Affirmative Action Director, University of California, Agriculture and Natural Resources, 1111 Franklin Street, 6th Floor, Oakland, CA 94607-5200 (510) 987-0097.

This publication is a continuation of the Water Resources Center Report series. It is published and distributed by the DIRECTOR'S OFFICE of the UC CENTER FOR WATER RESOURCES. The Center sponsors projects in water resources and related research within the state of California with funds provided by various state and federal agencies and private industry. Copies of this and other reports published by the Center may be obtained by contacting:

UC CENTER FOR WATER RESOURCES
WATER RESOURCES CENTER
RUBIDOUX HALL - 094
UNIVERSITY OF CALIFORNIA
RIVERSIDE, CA 92521
ATTENTION: PUBLICATIONS
(909) 787-4327

Copies of Center publications may be examined at:

Water Resources Center Archives
410 O'Brien Hall
University of California
Berkeley, CA 94720
(510) 642-2666

This publication is available on the web site of the UC Center for Water Resources. The URL is:
http://www.waterresources.ucr.edu.

Funding for this publication is provided by the University of California. It is available to the general public free of charge.

TABLE OF CONTENTS

From the Director

The Water Resources Center (WRC) was administratively combined with the Wildland Resources Center, the U.C. Salinity/Drainage Program, and the Cooperative Extension Water Quality Program into a unit known as the Centers for Water and Wildland Resources on July 1, 1993. The Wildland Resources Center was reassigned to another administrative unit during 1999-2000 and the three remaining programs are presently in the U.C. Center for Water Resources.

Professor Andrew Chang was appointed Associate Director of the UC Center for Water Resources effective June 1, 2001. Dr. Chang is Professor of Agricultural Engineering in the Department of Environmental Science at University of California, Riverside, and has a distinguished research and teaching record on water issues that is internationally recognized. He will assume many administrative responsibilities for the Water Resources Center Program, allowing me to devote more time to the U.C. Salinity/Drainage and Cooperative Extension Water Quality Programs.

A revision of the Water Resources Center by-laws approved at the April 6, 2000 Coordinating Board/ Advisory Council meeting expanded the role of the Advisory Council. The Advisory Council consists of representatives of the Department of Water Resources, State Water Quality Control Board, California Department of Fish and Game, the U.S. Geological Survey, as well as at-large membership from the water community.

The Coordinating Board is comprised of academic senate members from the U.C. Campuses and serves as the governing body of the Center. The Advisory Council participates with the Coordinating Board members in reviewing research proposals, serving on committees, and discussing business matters at the joint meetings.

Dr. John Letey

The largest proportion of the WRC budget goes to supporting research projects on a broad range of water-related issues. The annual progress reports on these projects are included within this publication. The projects serve the dual role of developing knowledge and training students.

The WRC provides the major support budget for the Water Resources Center Archives, located on the Berkeley campus. However, the financial and other support services by various donors and the Advisory Board to the Water Resources Center Archives are acknowledged and greatly appreciated. A more detailed report on the Archives is presented on page 10 of this annual report.

I take this opportunity to express appreciation and thanks to members of the Coordinating Board and Advisory Council for their contribution to the success of the WRC. They will be called upon for even greater service as we work together to increase the effectiveness and contributions of the WRC to addressing water issues in California.

About the Center

The Water Resources Center is the multicampus research unit in the University's Division of Agriculture and Natural Resources and is charged with stimulating and coordinating research and information dissemination on water. The Center was first funded in 1957 by the California legislature as a University-wide organized research unit. Over the years, its mission has expanded from an early focus on the State Water Project to one that encompasses virtually all water and water-related issues.

In 1964, the Center became part of a national network of university water research institutes when it was designated the California Water Resources Research Institute by the Governor and President of the University under the terms of the federal Water Resources Research Act of 1964. As the state's designated federal research institute, the Center is responsible for water research coordination and administration activities that extend beyone the University of California to all state and private universities in California. Since 1964, the Center has received federal funds and is subject to various federal policies and regulations.

The Center is organized with and Office of the Director on the Riverside campus, and an archives library on the Berkeley campus. The Director's Office also administers the Salinity/Drainage Program and the Water Quality Program. The Center does not undertake research directly, but supports an annual portfolio of between thirty and thirty-five projects on all phases of water reserach through its competitive grants program. This research is conducted by faculty and students within the departmental structure of each U.C. campus and those at other universities who successfully compete in the awards process.

Objectives

The basic goal of the Center is to stimulate and support water and water-related research both within and among the various academic departments and research organizations of the University. The broad research focus includes the conservation, development,management distribution and utilization of water resources with a view to their optimum present and future use. In order to achieve this goal, the Center operates according to the following long-standing functional objectives:

•Extend and intensify the water resources research program on all University of California campuses by widening the participation of individual researchers and disciplinary fields involved in water-related research, and to the extent feasible, by stimulating research in conjunction with academic programs:

•Identify substantive research agendas which, when pursuant, will assist in solving California's most urgent water problems and develop for the University major short- and long-term research priorities which are responsive to these problems:

•Maintain an inventory of water and water-related research within the University and assemble information on such undertaken throughout the United States and in other nations. Information on the current state of water and water-related research will be disseminated to University personnel, water managers, public interest organizations, and the interested public.

•Support and foster research which cuts across disciplinary boundaries and focuses on the interrelatedness of water with other natural resources such as energy and timber.

•Maintain close relationships with government agencies, quasi public organizations, and other research organizations for the purpose of keeping both the University and outside organizations aware of each other's activities and problems.

The Coordinating Board

The Coordinating Board establishes policy for the Center and makes final decisions regarding the allocation of available funds. It is chaired by the Vice President of Agriculture and Natural Resources, through whom it reports directly to the President of the University. The Board, appointed by the President of the University, is composed of at least thirteen faculty members from diverse disciplines and various administrative, teaching and research responsibilities. All members have a strong interest in water-related research. Eight of the nine campuses of the University are represented on the Board. The Board normally meets twice yearly (either in person or via phone conferencing), although special committees of the Board may meet from time to time throughout the year and individual members attend Center-sponsored meetings and conferences. Members serve as liasions or as contacts on their own campuses, as well as to agencies, citizens, faculty, and students in water-related research. These liasion interactions contribute valuable insights in establishing policy for the Water Resources Center. Members of the Coordinating Board during 2000-2001 were:

Richard Ambrose
Environmental Science and Engineering Program
Environmental Health Sciences
Room 46-081CHS, Box 951772
University of California
Los Angeles, CA 90024-1772
Phone: 310-825-6144
Email: rambrose@ucla.edu

Christopher Amrhein
Environmental Sciences
University of California
Riverside, CA 92521
Phone: 909-787-5196
Email: christopher.amrhein@ucr.edu

Louis W. Botsford
Wildlife, Fish and Conservation Biology
University of California
Davis, CA 95616
Phone: 530-752-6169
Email: lwbotsford@ucdavis.edu

Trudy Ann Cameron
Economics/Policy Studies
P.O. Box 951477
University of California
Los Angeles, CA 90095-1477
Phone: 310-825-3925
Email: tcameron@econ.ucla.edu

Andrew Chang
Environmental Sciences
1138 Geology Builiding
University of California
Riverside, CA 92521
Phone: 909-787-5325
Email: andrew.chang@ucr.edu

A. Russell Flegal
Environmental Toxicology
269 J. Baskin Engineering Building
University of California
Santa Cruz, CA 95064
Phone: 831-459-2093
Email: flegal@es.ucsc.edu

Stanley B. Grant
Chemical & Biochemical Engineering and Material Science
Zot Code 2575
University of California
Irvine, CA 92697
Phone: 949-824-7320
Email: sbgrant@uci.edu

Alexander J. Horne
Civil Engineering/CEE Environemental
609 Davis Hall
University of California
Berkeley, CA 94720-1710
Phone: 510-642-1089
Email: horne@ce.berkeley.edu

Helen Ingram
Urban Regional Planning
226 B SEI
University of California
Irvine, CA 92597-7075
Phone: 949-824-1434
Email: hingram@uci.edu

Miriam Kastner
Geosciences Research Division
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, CA 92093-0220
Phone: 858-534-0784
Email: mkastner@ucsd.edu

Hugo Loacigia
Geology
5712 Ellison
University of California
Santa Barbara, CA 93106
Phone: 805-893-8053
Email: hugo@geog.ucsb.edu

John Melack
Biological Sciences
Marine Science Institute
University of California
Santa Barbara, CA 93106
Phone: 805-893-3879
Email: melack@seaotter.ucsb.edu

Yoram Rubin
Civil Engineering/CEE Environmental
435 Davis Hall
University of California
Berkeley, CA 94720-1710
Phone: 510-642-2282
Email: rubin@ce.berkeley.edu

Ron Tjeerdema
Environmental Toxicology
College of Agricultural and Environmental Sciences
University of California
Davis, CA 95616
Phone: 530-754-5192
Email: rstjeerdema@ucdavis.edu

Bryan Weare
Land, Air and Water Resources
Atmospheric Sciences Program
One Shields Avenue
University of California
Davis, CA 95616
Phone: 530-752-3445
Email: bcweare@ucdavis.edu

The Advisory Council

The Advisory Coulcil consists of members from outside the University who are appointed by the President of the University. Former members who are particularly interested and active in Advisory Council affairs are invited to continue as "emeritus members." Membership includes distinguished engineers, attorneys, scientists, farmers, conservationists, and others who are prominent in water resources matters.

The Council members serve a very effective liasion function between the Water Resources Center and the public and private organizations that are involved in the management, development, control and use of water resources. Two full-day meetings are held each year, with the general purpose of providing forum of the improvement of current Center programs. The Advisory Council is particularly helpful in providing useful evaluations of research proposals as part of the Center's annual research review cycle. Members of the Advisory Council during 2000-2001 were:

Edward C. Anton
Acting Executive Director
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95817-0100
Phone: 916-657-0941
Email: antone@cwp.swrcb.ca.gov

Jeffrey W. Davis
Director
Water Resources Institute
5500 University Parkway
California State University
San Bernardino, CA 92407-2397
Phone: 909-880-7681
Email: jdavis@csusb.edu

William I. DuBois
Consultant
California Farm Bureau Federation
1127 11th Street, #626
Sacramento, CA 95814
Phone: 916-446-4647
Email: maredb@aol.com

Susan R. Ellis
Senior Environmental Specialist
California Department of Fish and Game
Office of Spill Prevention
P.O. Box 944209
1700 K Street, Suite 250
Sacramento, CA 95814
Phone: 916-327-3196
Email: sellis@dfg.ca.gov

Greg Gartrell
Contra Costa Water District
P.O. Box H2O
Concord, CA 94524
Phone: 925-688-8100
Email: ggartrell@ccwater.com

Rick Heimes
U.S. Geological Survey
Water Resources Division
Placer Hall -- 6000 J Street, Suite 2012
Sacramento, CA 95819-6129
Email: fjheimes@usgs.gov

Elise Holland
The Trust for Public Land
116 New Montgomery Street, Suite 300
San Francisco, CA 94105
Phone: 415-485-5660
Email: elise.holland@tpl.org

Mike Hollis
Metropolitan Water District
P.O. Box 54153
Los Angeles, CA 90054-0153
Phone: 800-225-7228
Email: mhollis@mwd.dst.ca.us

Vicki Kretsinger
Luhdorff and Scalmanini
500 1st Street
Woodland, CA 95695
Phone: 530-661-0109
Email: vkretsinger@lsce.com

Tom Martens
Executive Director
California Wildlife Foundation
1621 13th Street, Suite B
Sacramento, CA 95814
Phone: 916-446-2956
Email:
Tom_Martens@californiawildlifefoundation.org

Jonas Minton
California Department of Water Resources
1416 Ninth Street, Room 115-9
Sacramento, CA 94236-0001
Phone: 916-653-8045
Email: jminton@water.ca.gov

Eric M. Nichols
Principal Engineer
Levine-Fricke-Ricon, Inc.
1900 Powell Street, 12th Floor
Emeryville, CA 94608
Phone: 510-596-9533
Email: Eric.Nichols@LFR.com

Robert Reginato
1494 London Circle
Benecia, CA 94510-1353
Phone: 707-746-6626
Email: reginato@ix.netcom.com

Rita Schmidt Sudman
Executive Director
Water Education Foundation
717 K Street, #317
Sacramento, CA 95814
Phone: 916-444-6240, ext. 14
Email: rsudmad@water-ed.org

Michael Shulters
District Chief
US Geological Survey
Placer Hall -- 6000 J Street, Suite 2012
Sacramento, CA 95819-6129
Phone: 916-278-3000
Email: shulters@usgs.gov

Alexis Strauss
Environmental Protection Agency
EPA Water - 1
75 Hawthorne Street
San Francisco, CA 94105
Phone: 415-744-1860
Email: strauss.alexis@epa.gov

John D. Sullivan
Pitzer College
1050 N. Mills Avenue
Claremont, CA 91711
Phone: 909-607-3072
Email: john_sullivan@pitzer.edu

Walter C. Swain
Hydrologist
U.S. Geological Survey
Placer Hall -- 6000 J Street, Suite 2012
Sacramento, CA 95819-6129
Phone: 916-278-3024
Email: wcswain@usgs.gov

O.L.Van Tenney
Glenn-Colusa Irrigation District
P.O. Box 150
Willows, CA 95988
Phone: 530-934-8881
Email: vtenney@gcid.net

Leah Walker
California Department of Health Services
Drinking Water Technical Programs Branch
50 D Street, Suite 200
Santa Rosa, CA 95404
Phone: 707-576-2295
Email: lwalker2@dhs.ca.gov

Gary D. Weatherford
Weatherford and Taaffe, LLP
One Market Plaza
Stuart Tower, 16th Floor
San Francisco, CA 94105-1016
Phone: 415-357-1940
Email: H2Ogary@aol.com

Greg Woodside
Orange County Water District
10500 Ellis Avenue
P.O. Box 8300
Fountain Valley, CA 92778-8300
Phone: 714-378-3275
Email: gwoodside@ocwd.com

Ellen Yeoman
Senior Environmental Consultant
Pacific Gas and Electric
375 Wiget Lane
Walnut Creek, CA 94598
Phone: 925-974-4079
Email: ehy1@pge.com

Ex Officio Members

Bill Frost
County Director, El Dorado County
DANR--Cooperative Extension
311 Fair Lane
Placerville, CA 95667
Phone: 530-621-5509
Email: wefrost@ucdavis.edu

John Letey
Director
UC Center for Water Resources
Rubidoux Hall - 094
University of California
Riverside, CA 92521
Phone: 909-787-4327
Email: john.letey@ucr.edu

Lanny J. Lund
Assistant Vice President of Programs
DANR
300 Lakeside Drive, 6th Floor
Oakland, CA 94607
Phone: 510-987-0107
Email: lanny.lund@ucop.edu

Henry J. Vaux
Associate Vice President of Programs
DANR
300 Lakeside Drive, 6th Floor
Oakland, CA 94607
Phone: 510-987-0026
Email: henry.vaux@ucop.edu

Linda Vida
Librarian
Water Resources Center Archives
310 O'Brien Hall
University of California
Berkeley, CA 94720
Phone: 510-642-2666
Email: lvida@library.berkeley.edu

Research Activity by Campus

	2000-2001			2001-2002	
Location	**Projects Funded**	**Graduate Students Supported**	**Undergraduate Students Supported**	**New Projects**	**Total Projects**
UC Berkeley	9	15	11	1	10
UC Davis	8	15	12	4	12
UC Irvine	3	4	11	0	3
UC Los Angeles	4	6	0	0	4
UC Riverside	4	4	2	4	8
UC San Diego	0	0	0	0	0
UC Santa Barbara	3	5	6	0	3
UC Santa Cruz	0	0	0	1	1
TOTAL	31	49	42	10	41

Total research funds allocated during the 2000-2001 fiscal year:

Approximately $700,000

Total amount of funding WRC projects received from other sources:

Approximately $3.5 million

Information Program Activities

The Water Resources Center Archives

Mission and Scope

The mission of the Water Resources Center Archives (WRCA) is to develop and maintain a collection of water-related materials to meet the research needs of the University of California's system-wide instructional, research, and service programs. Established in 1957, the collection is relied upon by the University community as well as government agencies, corporate professionals, and the public.

WRCA is a research library with more than 143,000 cataloged items. The scope of the collection includes fresh water supply and quality, groundwater, municipal and industrial water uses, flood control, water reuse, sewerage and waste disposal, river mechanics, coastal engineering, estuaries, water pollution, and water law. WRCA collects a variety of types of materials including printed reports, government documents, books, manuscripts, maps, videos, photographs, and electronic resources. The collection concentrates on materials relating to California and the West, although there are national and international materials in the collection as well.

Access to the Collection

WRCA is a member of the Online Computer Library Center (OCLC), an international database that currently contains more than 45 million records in the Library of Congress' Machine Readable Catalog (MARC) format. The system indicates which member library holds a given title, and is both a shared cataloging resource and interlibrary borrowing mechanism. Since 1983, all new WRCA material has been cataloged onto the OCLC database.

OCLC regularly uploads all of the recent cataloging records from all nine UC campuses. This cumulative tape is then uploaded to the Melvyl ® Catalog, the University of California's online catalog database. Melvyl® is searchable on the World Wide Web (http://www.melvyl.ucop.edu). This makes the WRCA's collection available nationally and internationally.

In October 1998, WRCA became a participant in the California Digital Library's Online Archive of California (OAC), a union database of encoded archival finding aids. Finding aids provide detailed descriptions and outlines of archival collections and are essential tools for understanding the true content of a particular collection. The OAC is searchable at the collection, repository, and institutional levels, or the entire database can be searched for documents or photographs on particular subjects. Currently the Water Resources Center Archives has over 100 finding aids on the OAC, which expands use of the archival collections. WRCA's collections can be found at http://www.oac.cdlib.org/dynaweb/ead/berkeley/wrca.

In September 2000, WRCA purchased four new PC's for the public to replace the dedicated Wyse

terminals. The new terminals were needed to allow patrons to search the California Digital Library and use all of the functionality of the World Wide Web.

Use of the Collection

Use of the collection in 2000-2001 included 11,364 transactions (titles used on the premises and borrowed). Users, by category, were as follows: graduate students - 22%, undergraduate students - 7%, faculty and staff - 7%, interlibrary loans - 17%, general public - 47%.

California Colloquium on Water

In fall 2000, WRCA, in conjunction with the Center for California Studies, Boalt School of Law, and the Colleges of Engineering, Natural Resources and Letters & Science started a new lecture series. The *California Colloquium on Water* series hosts four lectures each semester on the second Tuesday of the month. Distinguished speakers from the fields of natural sciences, engineering, social sciences, humanities and law are invited to speak to students, faculty and the general public about water resources in order to contribute to informed decision making. All lectures are free. Speakers and topics presented in the fall and spring series were as follows:

Fall 2000

September	Gerald Orlob, Professor Emeritus, UC Davis: *Saving the Salton Sea*
October	Peter Gleick, Director, Pacific Institute for Studies in Development, Environment & Security: *Global Warming*
November	Leah Wills, Economist, Plumas Corporation: *Upstream Watersheds*
December	Peter Palmquist, Photographer and Author: *19th Center Water Images in California*

Spring 2001

February	Arthur Littleworth, Attorney, Best Best & Krieger: *Are we going to run out of water in California?*
March	Ronald Gastelum, General Manager, Metropolitan Water District of Southern California: *MWD: Challenges in a Changing California*
April	Richard Denton, Water Operations Manger, Contra Costa Water District: *Understanding the Sacramento-San Joaquin Bay-Delta–An Engineering Perspective*
May	Richard Saykally, Professor, UC Berkeley, College of Chemistry: *What Makes Water Wet?*

WRCA Publications

WRCA produces two publications - *Selected Recent Accessions*, a bi-monthly list of new publications, and *WRCA News*, a newsletter that is published three times per year. These publications are distributed free-of-charge in paper format to approximately 400 subscribers. They are also available in electronic format on the WRCA web site (http://www.lib.berkeley.edu/WRCA/).

The Water Resources Center Archives and the Harmer E. Davis Transportation Library collaborated on the publication of a calendar for the year 2001 that featured historic photographs of the Golden Gate Bridge and the San Francisco-Oakland Bay Bridge under construction. All of the photographs are from the Charles Derleth, John Debo Galloway and Walter Leroy Huber manuscript collections held by WRCA. The calendar was published with generous sponsorship from T.Y. Lin International/Moffatt & Nichol Engineers, a joint venture. Thirteen hundred calendars were distributed to donors of the two libraries and sold in local bookstores, or via mail order.

The two libraries have recently completed

compiling a calendar for the year 2002 featuring images of historic San Francisco Bay ferries. The images are from the pictorial collections of the National Maritime Institute located in San Francisco. Publication of the 2002 calendar will be sponsored by Moffatt & Nichol Engineers.

Web Site and Online Resources

The Water Resources Center Archives continues to develop and expand its web site. The web site includes an introduction to the library's print and electronic resources, lists of archival and video collections, specialized research guides, and all library publications. It also provides links to the California Digital Library (which includes Melvyl® and the Online Archive of California), electronic reference resources, article indexes, electronic journals, and other online resources. In July 2000, the Internet Resources section of the WRCA web site was selected as a "Key Resource" by Links2Go, an extensive Internet search and directory service (http://www.links2go.com/topic/Hydrology).

The online resources provided by the Water Resources Center Archives help researchers get up-to-date information. Different systems provide information in bibliographic, full-text, or data forms. *Water Resources Abstracts* contains bibliographic citations to journals, books, documents, and reports on hydrology and other areas of water-related research. This system is now accessible to UC Berkeley students, faculty, and staff via the WRCA web site. WRCA also maintains subscriptions to two key CD-ROM databases: *U.S.G.S. Peak Values* and *U.S.G.S. Daily Values*, both published by Hydrosphere, Inc. WRCA staff members are experts at locating and retrieving data and information from all of these electronic resources.

Fundraising and Fee-For-Service

WRCA continues its fundraising activities. In 2001, approximately four hundred letters were sent to California Water or Irrigation Districts asking them to become members of the Archives. The Advisory Board to the Water Resources Center Archives continues to meet semiannually and to assist with outreach and fundraising strategies.

WRCA continues to expand the use of the collection and increase outside revenues by providing fee-based document delivery services to non-UC requestors. Requests are received via OCLC, telephone, fax, or e-mail.

Conferences, Exhibits and Receptions

On March 1, 2000, WRCA celebrated the installation of *Bridging the Bay: Bridging the Campus*, an exhibit, which contained a wide selection of historical and contemporary materials showcasing the building of the Bay Area's bridges. The exhibit was a collaborative effort featuring materials from eight libraries on the UC Berkeley campus, including extensive materials from WRCA's archival collections. Exhibit curators were Linda Vida, WRCA, and Waverly Lowell, UCB Environmental Design Archives. Randal Brandt, WRCA, was the curator of the virtual exhibit.

On June 17, 2001, Virtual Curator Randal Brandt received the Katharine Kyes Leab & Daniel J. Leab *American Book Prices Current* Exhibition Award for the online exhibit, *Bridging the Bay: Bridging the Campus* (http://www.lib.berkeley.edu/Exhibits/Bridge/). The Leab Awards, presented by the American Library Association, Association of College and Research Libraries, Rare Books and Manuscripts Section, are given annually for excellence in the publication of printed library and archival exhibition catalogs, brochures, and electronic exhibitions. Criteria for granting these awards include originality, accuracy of detail, informational content, visual impact, contribution to scholarship, and usefulness to the intended audience. *Bridging the Bay* was selected for its overall graphic design and easy site navigation. This on-line exhibition exemplifies the great possibilities that the World Wide Web holds

for successful collaborative projects between a number of different repositories of printed and archival materials.

On May 30, 2001, WRCA and The Bancroft Library's Regional Oral History Office (ROHO) celebrated the completion of the Central Valley Project Improvement Act (CVPIA) and the Baumberg Tract oral history projects. A reception was held in the Stebbins Lounge of the Women's Faculty Club. Thomas Graff of Environmental Defense spoke about his experience participating in the CVPIA series, and Bob Douglass, Cargill Salt, spoke about his experience participating in the Baumberg Tract oral history. Mala Chall, who had been the interviewer for both of these series also spoke and was commended for her skills as an interviewer.

Grants

In May 2000, the Water Resources Center Archives was awarded a $15,000 grant from the San Francisco Foundation to create an online inventory of projects receiving grants from the Foundation's Bay Fund. WRCA used this grant to develop an inventory and online map that includes all San Francisco Bay Fund projects. WRCA also developed a web site and linked that inventory with other related restoration information systems. In May 2001, WRCA was awarded a follow-up grant for $10,000 to continue to add newly funded projects to the online system and upgrade WRCA's Bay Fund web site.

The inventory is housed on the Information Center for the Environment's (ICE) web-based system at UC Davis (http://ice.ucdavis.edu/). ICE hosts a variety of inventories offering information about restoration, mitigation and conservation projects in, or bordering, California. The inventory is a file in the Natural Resource Projects Inventory (NRPI). An important component of the grant is the design and implementation of a community outreach effort to contact schools, libraries, local organizations and businesses to increase awareness of the inventory and encourage its use. In May 2001, a postcard was sent out to over 200 Bay Area public libraries and schools announcing the SF Bay Fund web site located at http://www.lib.berkeley.edu/WRCA/bayfund/

The Water Resources Center Archives was also awarded a grant for $7,500.00 from the Librarians Association of the University of California (LAUC). Today there are approximately 500 active water and irrigation districts in California. However, no comprehensive up-to-date directory of these districts exists, nor has there been a survey performed to identify what, if any, historical research materials have been created and maintained by these districts. The grant allowed the Archives to survey California water and irrigation districts in order to create a comprehensive list of water districts and irrigation districts and to include basic information about each district. At the same time, a survey of these agencies' significant historical documents was conducted. The Archives sent out approximately 450 survey forms. Respondents were encouraged to fill out the survey online and submit it via email. Approximately 110 forms were returned. This information was compiled and organized in a searchable Access database that is available at the Water Resources Center Archives.

Water Resources Center Publications

The publication and distribution of the results of sponsored research projects are important functions of the Center's program. The various publication categories produced by the Center are:

Contribution Series. Published refereed technical monographs which are generated from Center sponsored research projects;
Report Series. Publications which are less technical and appeal to a wide audience. Examples of this Report Sreies include the Annual Report, Proceedings of Center-sponsored conferences and symposia, and interpretive summaries of research projects;
Miscellaneous. An unnumbered series of non-technical publications on topics relating to California's water resources development, use and management.
Technical Completion Reports. All Center-sponsored projects file a Technical Completion Report (TCR) which is the formal professional summary that covers all elements of the project. Such reports may be reviewed in the Director's Office and in the Water Resources Center Archives on the Berkeley campus. Although unpublished TCR's are not for general distribution, copies will be provided upon request.

Through the office, the Center for Water Resources has filled approximately 90 requests for publications. A total of 1,500 publications (volumes) were distributed worldwide to interested parties both in the public and private sectors. Most of the Center's publications are available at no charge, and a listing of available publications can be found on the Center's web site (http://www.waterresources.ucr.edu). When the Center's supply of a publication is depleted, the publication can often be obtained from the National Technical Information Service (NTIS) for a fee. Recent Center publications are downloadable from the Center's web site. A complete set of Center publications is available at the Water Resources Center Archives at 410 O'Brien Hall on the UC Berkeley campus. In addition to Technical Completion Reports from sponsored research, the Center produced the following publications during 2000-2001:

- 2000.Water Resources Center Annual Report, July 1, 1999-September 30, 2000. Water Resources Center Report No. 100. 83 p.
- 2000. *Numerical Simulation of Land Subsidence in the Los Banos-KettlemanCity Area, California.* Water Resources Center Contribution No. 207. 83 p.
- 2000. *Managing Watersheds in the New Century: Proceedings of the Eighth Biennial Watershed Managment Council Conference.* Water Resources Center Report No. 101. 201 p.

Other Public Service and Information Activities

The Director of the Center continues to participate in the National Institute for Water Resources (NIWR). The Water Resources Research Institute Program (WRRIP) was established by Congress in 1964 and consists of fifty-four institutes at the nation's Land Grant institutions. The National Institute for Water Resources is a coalition of these institutes organized to collaborate, communicate and network with each other on important water resources issues. The URL for NIWR's web site is http://wrri.nmsu.edu/niwr/. It lists all fifty-four institutes, the programs, events and publications within each institute, and summaries of each institute's research projects.

The institutes have established themselves as a primary link between the academic community and water resources personnel in government and private sectors. Training future water professionals is one of the primary missions of WRRIP. Each year WRRIP-supported projects provide training for more than 100 students nationally. WRRIP also provides the framework for a national network of water researchers, promotes innovative

solutions to water-related problems, and encourages a bottom-up approach to water resources problem identification and solution.

Each year, the Center submits a report to WRRIP which contains the annual report for eah WRRIP-supported project at the Center, all publications and presentations, total students trained by academic level/discipline, and significant accomplishments of the Center.

Direct contact with principal investigators is an important source of information concerning research work. Campus addresses, phone numbers and email addresses are provided in the Principal Investigator Index section of this report on page 60. Interested readers are directed to contact individual principal investigators to obtain reprints of journal articles as well as additional information on their research projects.

Many of the research narratives summarized in this report include a list of publications which reflect the principal investigator's research in detail as published in professional and technical journals.

Libraries throughout the United States and in foreign countries receive copies of all Water Resources Center publications.

The Center for Water Resources, in collaboration with the Water Education Foundation has developed a quarterly newsletter titled *Currents*. *Currents* is mailed to over 4000 recipients and is available online at http://www.waterresources.ucr.edu. Each edition of *Currents* highlights funded research by the UC Center for Water Resources, recent achievements of funded principal investigators, and upcoming special events and conferences.

Research Project Index

Research Category I -- Hydrology, Climatology and Hydraulics

Research Category II -- Aquatic Ecosystems

Project #	Project Title	Principal Investigator(s)	UC Campus	Page
W-925	*Habitat Features and Aquatic Health: Evaluating California's Stream Bioassessment Procedure in Natural and Artificial Streams in Grazed Eastern Sierra Valley*	Kenneth W. Tate and Linda K. Vance	Davis and Davis Cooperative Extension	41
W-928	*How California Fishes Swim Upstream Past Rapids, Waterfalls and Human-Made Barriers*	Malcolm S. Gordon	Los Angeles	43
W-930	*The Influence of Introduced Trout on the Diversity and Structure of Native Aquatic Invertebrate Communities in High Sierran Streams*	David B. Herbst and Scott D. Cooper	Santa Barbara	45
W-933	*Freshwater Mussels in California's North Coastal Streams: Current Status and Geomorphologic Controls*	Kurt Cuffey	Berkeley	47
W-937	*Examining the Relative Influences of Riparian and Upland Land Cover and Land Use on Instream Habitat: Improved Methods for the Russian River Basin.*	Nina Maggi Kelly and Adina Merenlender	Berkeley and Hopland Research and Extension Center	49
W-940	*Conservation Genetics of the Tidewater Goby* -- Eucyclobious Newberryi	David Jacobs	Los Angeles	51
W-946	*Assessing the Response of Degradative Biofilms to Groundwater Pollutants*	Jay D. Keasling	Berkeley	53
W-947	*Bed Texture, Food Web Structure, and Juvenile Salmonid Rearing in North Coast California Rivers*	Mary E. Power	Berkeley	56
W-948	*An Evaluation of Invasive Species in Lake Tahoe: The Potential Impace of Bass Species on the Lake Ecosystem and Mercury Food Web Transfer*	Darrell G. Slotton	Davis	58

Research Category III -- Water Quality

Research Category III -- Water Quality, continued

Project #	Project Title	Principal Investigator(s)	UC Campus	Page
W-945	*Biodegradation of Estrogenic Compounds and Its Enhancement in a Membrane Bioreactor*	Slawomir W. Hermanowicz	Berkeley	82

Research Category IV -- Water Development and Management Alternatives

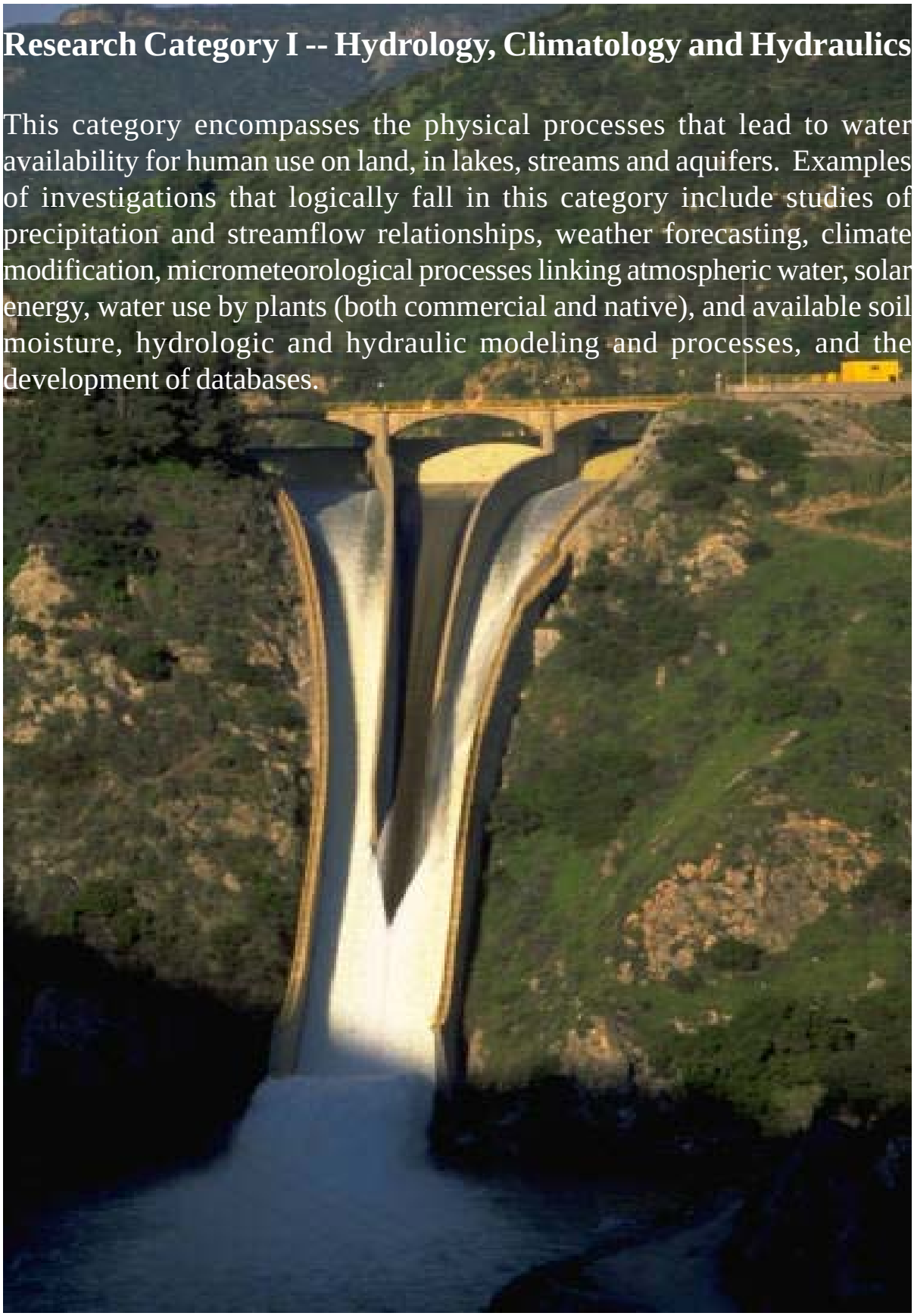
Project #	Project Title	Principal Investigator(s)	UC Campus	Page
W-934	*Modeling and Optimization of Water Quality in a Large-Scale Regional Water Supply System*	William W-G. Yeh	Los Angeles	87

Research Category V -- Water Law, Institutions and Policy

Project #	Project Title	Principal Investigator(s)	UC Campus	Page
W-921	*Mechanisms for Addressing Third-Party Impacts Resulting from Voluntary Water Transfers*	Richard E. Howitt	Davis	91
W-926	*An Integrated Modeling Framework for Analyzing Wetlands Policies: Balancing Ecosystem Services and Economic Factors*	Marca Weinberg and Stephen C. Newbold	Davis	93
W-936	*Multilateral Negotiation: Coalition Formation and California Water Policy*	Rachel Goodhue, Gordon Rausser and Leo Simon	Davis and Berkeley	95
W-941	*Negotiating Contentious Claims to Water: Shifting Institutional Dynamics for the Allocation of Water Between the Eel and Russian River Basins*	J. Keith Gilless	Berkeley	97

Research Category I -- Hydrology, Climatology and Hydraulics

This category encompasses the physical processes that lead to water availability for human use on land, in lakes, streams and aquifers. Examples of investigations that logically fall in this category include studies of precipitation and streamflow relationships, weather forecasting, climate modification, micrometeorological processes linking atmospheric water, solar energy, water use by plants (both commercial and native), and available soil moisture, hydrologic and hydraulic modeling and processes, and the development of databases.



Study of Groundwater Dynamics in the Kern Alluvial Fan, California

Jordan Clark
Geological Sciences
UC Santa Barbara

Hugo A. Loaiciga
Geography
UC Santa Barbara

Near Aquifer Storage and Recovery (ASR) operations, the dynamic movement of groundwater affects the management of the operation. Using both geochemical tracers and numerical modeling, the dynamics of the groundwater flow system near the Kern Water Bank (KWB) was examined during this 2-year project. The KWB is a 78 km^2 ASR operation located in the Kern River alluvial fan at the southern end of the San Joaquin Valley, Kern County, California. Groundwater samples were collected at 10 and 13 locations in the KWB in January and August of 2000, respectively. At each location, aliquots of water were extracted from a shallow and a deep monitoring well after they had been flushed with five well volumes. The samples were analyzed for general chemistry, chlorofluorocarbons (CFC-11 and CFC-12), and stable isotopes of the water ($^{18}O/^{16}O$ and $^{2}H/^{1}H$).

The distribution of young water in the aquifer is consistent with the recent recharge history at the Kern River Bank. The CFC data indicate that the relatively young groundwater (<15 yr) is found in the northern and central regions of the KWB at shallow depths. An intermediate aged (15 to 40 yr) groundwater component is encountered in the deeper wells of the northern and central regions. The oldest water (> 50 yr) is found in the southern and western areas. At each location, the water found in the deeper layer of the aquifer is usually older. This age distribution is consistent with the recent history of artificial recharge at the KWB. The stable isotopic composition of water and the major ion chemistry did not correlate well with either geography or groundwater age. Hence, these geochemical tracers could not be used to identify the recently recharged surface water.

The distribution of young water in the aquifer is consistent with the recent recharge history at the Kern River Bank.

A hydrogeologic model was developed using the Visual Modflow™ Software. The model is composed of three layers (total thickness 226 m), representing the aquifer structure and permeability. Each layer is built on a 58 columns, 39 rows grid consisting of 1935 active cells ranging in size from 0.16- 0.65 km^2 and 327 inactive cells located in southwestern corner of the grid. The model is built with hydrogeologic parameters, monitoring/ production well data, and assumed boundary and initial conditions. The California Department of Water Resources hydrogeologic data sets were transferred into our model. Field data entered into the model for simulation included: (i) the initial groundwater surface in spring 1994, (ii) the 1994 – 2000 artificial recharge rates at the KWB, (iii) 1994 – 2000 hydraulic heads records at 26 monitoring wells and (iv) 1994 – 2000 pumping rates at productions wells. The calibrated model was run over a 7-year simulation period (1994 -

Keywords

Groundwater banking
Tracers
Chlorofluorocarbons
Groundwater modeling
Kern Water Bank

2000) in a transient mode, with twelve time steps for each stress period. The root mean squared error between simulated and measured hydraulic heads of monitoring wells in KWB was calculated at 8 m. The CDWR numerical flow model used in this study was optimized for an earlier time period, under different recharge and pumping rates. This hydrological model responded well to the more recent hydrological inputs we integrated in this study.

Professional Presentations

A poster was given on the results of this project at the annual meeting of the American Geophysical Union, December 2000.

Meillier, L.M., J.F. Clark and H.A. Loaiciga, Groundwater Bank Dynamics in the Kern Alluvial Fan, Bakersfield, CA, USA.

Training Accomplishments

Laurent Meillier: Graduate Student (M.S.,UC Santa Barbara Geology, 2001)
Jeff Gamblin: Undergraduate at the UC Santa Barbara Geology Department

A Stochastic Sediment Supply Model for a Semi-Arid Landscape

Thomas Dunne
Geological Sciences
UC Santa Barbara

We are investigated the delivery of sediment from hillslopes into channels by directly linking climatic events (including fires) with sediment transport processes. Watersheds in semi-arid regions are subject to a variety of disturbances, including grazing, fires, and vegetation cover changes. Our goal is to determine how these disturbances affect the magnitude, frequency, and spatial distribution of sediment delivery processes.

Sediment loading from hillslopes can have an impact on a range of concerns in Southern California and other subhumid, mountainous environments elsewhere. As the urban fringe continues to climb higher into the surrounding foothills and mountains, the potential loss of life and property from geological hazards such as runoff and debris flows will escalate. In turn, the delivery of fine-grained sediment from hillslopes is a major contributor to non-point source pollution of the receiving water bodies. As population centers expand, the issue of water quality for both human consumption and riverine ecosystems will only increase through time. In addition, the storage capacities of many reservoirs in sub-humid mountainous areas around the world are being reduced by sedimentation. Because hillslopes are the main source of sediment to rivers in subhumid, mountainous landscapes, the ability to forecast this sediment loading is essential in .

This past year, our work focused on examining the sediment transport by surface runoff though rainfall simulation experiments. In 1999, we built a mobile rainfall simulator capable of covering a 15 m^2 plot. Data from experiments on a variety of plots varying by vegetation cover, vegetation density, and hillslope gradient were used to calibrate an equation for predicting sediment loss by surface runoff. Furthermore, we collaborated with an ecologist from the Department of Evolution, Ecology, and Molecular Biology who analyzed the nutrient content of surface runoff samples to predict nutrient losses as well as sediment losses. This is an important component of this project because nutrient loss from hillslopes affects soil fertility while nutrient delivery to rivers and streams may lead to eutrophication. The effects of grazing on the runoff process were investigated by simulating the cattle trampling. Even very light trampling can dramatically alter the hydrological properties of the soil, leading to accelerated runoff

The effects of grazing on the runoff process...even very light trampling (by cattle) can dramatically alter the hydrological properties of the soil, leading to accelerated runoff and erosion (on hillslopes).

Keywords

Sediment delivery
Fire
Shallow landslides
Overland flow
Grazing impacts

and erosion. Subsequently, results from the rainfall simulations were incorporated into a computer model of runoff and erosion to estimate sediment and nutrient losses from entire hillslopes. This model has been used to evaluate effects of various land management strategies as well as climate change on sediment and nutrient delivery.

Publications

Gabet, E.J., S. Mudd and M. Reimer. The effects of particle size on debris flow mobilization. To be submitted to *Geology*, Dec. 2001.

Gabet, E.J. Nonlinear hillslope diffusion by dry ravel. To be submitted to *Geology*, Nov. 2001.

Fierer, N. and E.J. Gabet. The transport of carbon and nitrogen by surface runoff by hillslopes in the Central Coast region of California. To be submitted to *Journal of Environmental Quality*, Sep. 2001.

Gabet, E,J. and T. Dunne. Sediment detachment by rain power. Submitted to *Water Resources Research*, Jul. 2001.

Gebet, E.J. Gopher bioturbation: Field evidence for nonlinear hillslope diffusion. *Earth Science Processes and Landforms*, 25(13): 1419-1428. 2000.

Professional Presentations

Fierer, N. and E.J. Gabet. The efect of vegetation type on the transport of nutrients from hillslipes in Central California. *EOS Transactions AGU*, 81(48), Fall Meeting Supplement F302. 2000

Training Accomplishments

Two graduate students.

Additional Funding

1998-2000, Milderd Mathias Research Grant, UCNRS, $4,500.00.

Understanding and Predicting Seasonal-to-Interannual Fluctuations in California Precipitation Using an Atmospheric General Circulation Model

John D. Farrara
Atmospheric Sciences
UC Los Angeles

Jin-Yi Yu
Atmospheric Sciences
UC Los Angeles

The water supply in California is subject to large fluctuations on a variety of timescales ranging from intraseasonal to decadal. This variability has been clearly evident from events in recent years with extremes that include both the abundant supplies during 1983, 1986, 1993, and 1997-98 and the multi-year drought of 1987-1992. The primary sources of water in California have their origins in precipitation associated with winter storms originating over the North Pacific Ocean. Thus, the variability in the frequency and intensity of winter storms is a major cause of variations in water supplies. It is known that a significant amount of the interannual variability in the Pacific storm track is related to variations in sea surface temperatures (SSTs) in the tropical eastern Pacific Ocean - El Niño and La Niña events. However, the precipitation events in California does not always respond according to the SST and extreme events such as the flood of January 1997 may occur even when tropical Pacific SST anomalies are weak, suggesting that other mechanisms may be important. The natural variability of the Pacific storm track is one such possible mechanism. Our research uses numerical models of the global atmosphere to better understand the relative importance of different mechanisms in producing the variations of precipitation in California.

...the natural variability is the dominant factor influencing the intensity and position of the Pacific storm trac in years when tropical sea surface temperature anomalies are relatively weak... suggest that there may be clear limits to our ability to make seasonal forecasts in the absence of strong tropic sea surface temperature anomalies

Our research suggests that the natural variability is the dominant factor influencing the intensity and position of the Pacific storm track in years when tropical SST anomalies are relatively weak. For example, significant differences were observed in California winter precipitation during 1999-2000 and 2000-2001 although the extents of SST anomalies (weak) in these two seasons were similar. The results of our prediction exercises for the two winters showed the influences of these events. For this exercise, we had available predictions of SST for the tropical Pacific Ocean. The SSTs in this region were very similar in these

Keywords

California water supply
Rain
Snow
Drought
Flood
El Niño
Numerical modeling of the atmosphere
Seasonal to interannual prediction

two winters and, therefore, our AGCM-based forecasts were very similar. The unpredictable component, the natural variability, that was unaccounted for in the modeling however was sufficiently large to cause the significantly different precipitation patterns in these two winters. The results suggest that there may be clear limits to our ability to make seasonal forecasts in the absence of strong tropical SST anomalies.

Publications and Presentations

Farrara, J. D., A. W. Robertson and C. R. Mechoso, 2000: Ensembles of two-tier simulations and predictions of the circulation anomalies during winter 1997-98. Mon. Wea. Rev., 128, 3589-3604.

Farrara, J. D. and J.-Y. Yu, 2000: Interannual variability of the North American Monsoon: Preliminary results of a study using the UCLA AGCM. Presentation at the 25th Climate Diagnostics and Prediction Workshop, October 23-27, 2000, Palisades, NY.

Training Accomplishments

Ms. Ying Teng, who has been supported the project since January 2000, has completed all the requirements for her Masters degree in Atmospheric Science.

Collaborative Efforts

The research enabled by this grant was a factor in the success of a second proposal to the NOAA Pan-American Climate Studies/GCIP Program on warm season precipitation. The three-year proposal, entitled "Evaluating the importance of land-surface processes for seasonal predictions of regional climate in the United States " was funded in the amount of $235,000.

Evaluation of the Effects of Surface Water and Groundwater Interactions on Regional Climate and Local Water Resources

Xu Liang
Civil and Environmental Engineering
UC Berkeley

Knowledge on the state of soil moisture is essential for improving predictability of the global energy and water balances on seasonal to inter-annual time scales. The exchanges of moisture and energy between soil, vegetation, and snowpack and the overlying atmospheric boundary layer impacts the near surface atmospheric moisture and temperature. Thus, reasonable estimates of soil moisture could significantly improve the accuracy of simulating precipitation and surface temperature globally and regionally. If the soil moisture estimation (or parameterization) is not reliable, a fully coupled climate and land surface model may result in predicted precipitation and temperature that deviate significantly from observed values, especially for extreme events.

Important processes that are closely related to the dynamics of soil moisture fluctuations, but not yet well represented, should be incorporated into the soil moisture estimation, such as the groundwater and surface water interactions. Under both shallow and deep water tables, the soil moisture is influenced by the groundwater and surface water interactions. Field observations show that the interactions between surface water and groundwater may alter hydrological consequences, such as runoff production, water table fluctuations, and surface hydrology. This project quantifies effects of surface water and groundwater interactions on regional climate and local water resources through the dynamic representation of soil moisture distribution within the soil column.

Two major tasks have been accomplished:

1. Developed and tested offline the method that represents the water table dynamically. It was further modified, based on results of the offline testing.

2. Coupled the module that dealt with the groundwater and surface water interactions dynamically into the VIC-3L (Three-Layer Variable Infiltration Capacity) land surface model to quantify effects of surface water and groundwater interactions on soil moisture distribution and on the partitions of water and energy budgets.

The coupled VIC-3L model was used to simulate the daily groundwater table fluctuations in three watersheds, with drainage areas ranging from less than 1 km^2 to over 400 km^2, for 2.5 years. The comparisons showed good agreements between the observed daily groundwater tables and the model simulated ones (Figure 1). The soil moisture distribution and evapotranspiration between simulation results that considered and not considered the effects of groundwater and surface

Keywords

Surface water and groundwater interactions
Soil moisture
Spatial scales
Land surface model
Water resources management
Water quality assessment

water interactions were compared. The results show that the difference in soil moisture is significant. Also, the different soil moisture estimated over the 2.5 years in these two cases resulted in approximately 14% difference in the evapotranspiration for the same time period.

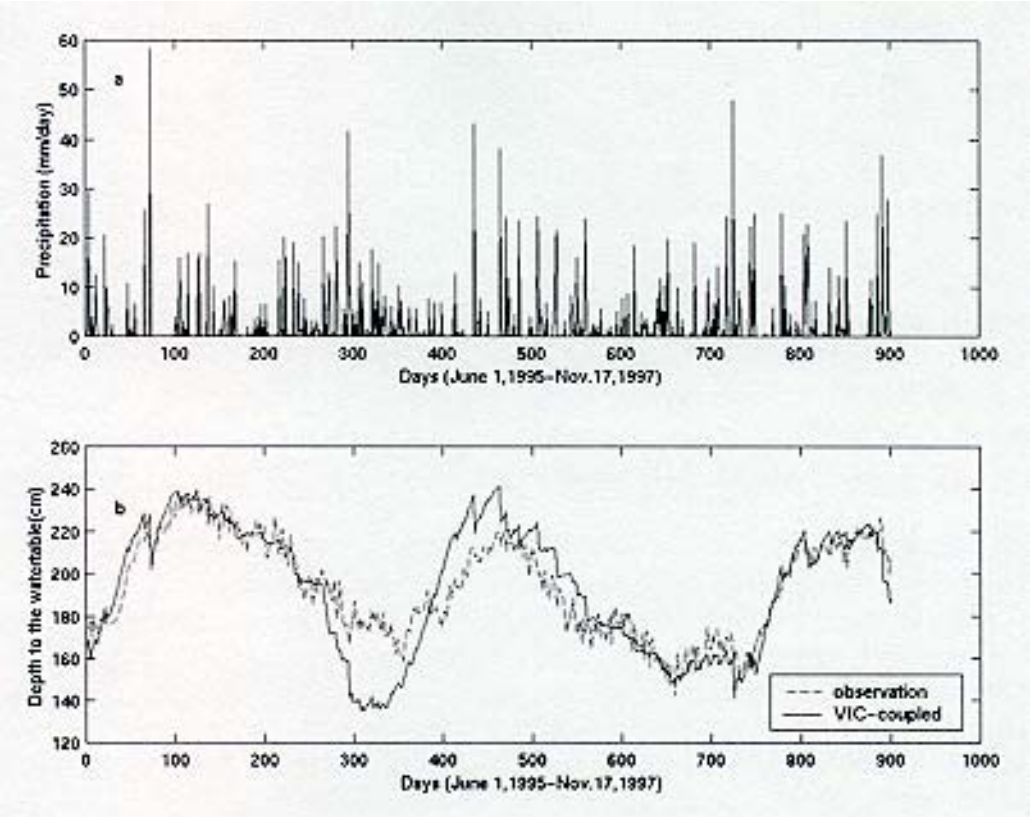


Figure 1. (a) Daily precipitation time series between June 1, 1995 and November 17, 1997. (b) The corresponding observed and simulated groundwater table fluctuations.

Publications and professional presentation

Xie, Z., and X. Liang, A study of surface water and groundwater interactions for land surface schemes, AGU Fall meeting, San Francisco, Dec. 2000.

Liang, X., and Z. Xie, The impact of groundwater and surface water interactions on water and energy budgets of land surface models, in preparation for Water Resour. Res., 2001.

Training accomplishments

Dr. Zhenghui Xie

Through the funding from this project and a NOAA project, Dr. Xie finished his two year postdoctoral research position. The research experience with the project has helped him greatly to obtain a faculty position.

Soil Water Monitoring Using Geophysical Techniques: Development and Applications in Agriculture and Water Resources Management

Yoram Rubin
Civil and Environmental Engineering
UC Berkeley

The soil water is vital for biomass production of and ecological processes in the terrestrial ecosyetems. The information obtained from monitoring soil water contents is critical for optimizing crop yields, achieving high irrigation efficiencies, planning irrigation scheduling, and minimizing lost yield due to waterlogging and salinization. Such water content monitoring is also important for addressing water quantity and quality issues, relevant for managing the environmental impacts of irrigated agriculture and protecting functional ecosystems. Our research focuses on investigating the applicability of a surface geophysical method, ground penetrating radar (GPR), as a tool for estimating soil water content. Successful development of the methodology could lead to water management tools that help to increase water savings, reduce energy expenditures, and better understanding of the ecology of natural vegetation.

The key findings of this study to date are listed below:

1) Data from controlled test pit suggested that the travel time of the GPR signal can provide reliable soil water content estimates under a variety of saturation conditions. The moisture content estimates from GPR data were within 1% of the values obtained from the more conventional but laborious gravimetric point measurement technique.

The ground penetrating radar groundwave travel time and amplitude information, collected using different frequency antennas, can yield very accurate and high spatial resolution soil moisture content information.

2) GPR groundwave travel time and amplitude information, collected using different frequency antennas, can yield very accurate and high spatial resolution soil moisture content information. Comparison of this information with time domain reflectometry (TDR) measurements reveal that the GPR groundwave analysis provides more accurate and dense information about moisture content than the conventional TDR technique. GPR methods also provide the information in a less invasive manner than the TDR techniques.

3) The information provided by the surface GPR had much higher resolution and better accuracy

Keywords

Soil moisture
Ground penetrating radar
Precision vineyard management
Hydrogeological property estimation
NDVI (normalized difference vegetation index)
Remote sensing

than information provided by surface electromagnetic techniques, which heretofore had been the 'benchmark' geophysical technique for providing information about near surface soil moisture content.

4) The near surface moisture content values, estimated using GPR, appear to have a correlation with near-surface soil texture and with normalized difference vegetation index (NDVI) obtained from remote sensing data collected over the Mondavi study site.

5) Geostatistical analysis of the conventional TDR-generated moisture content measurements and the moisture content estimates obtained using GPR suggest that the spatial correlation model of volumetric moisture content obtained using conventional measurement tools are heavily influenced by the (typical) spatial sampling of the measurements and thus may provide misleading information about the correlation structure. This problem can be alleviated using the dense moisture content information obtained from surface GPR data.

Publications

Grote, K, Hubbard, S., Kowalsky, M. and Rubin, Y., High Resolution Estimation of Subsurface Water Content using surface GPR, in preparation for *Water Resources Research*, 2001.

Hubbard, S., Grote, K. and Rubin, Y., Development of GPR Techniques to Non-Invasively Measure Subsurface Water Content, Earth Science Division LBNL Annual Report, 2000

Grote, K., Hubbard, S., Lawrence, A., Harvey, J. Riemer, M., J. Peterson and Rubin, Y., Nondestructive Monitoring of water content using surface ground penetrating radar techniques, *EOS* 80(46), PF291, 1999.

Professional Presentations

Hubbard, S., Grote, K, Kowalsky, M. and Rubin, Y., Precision Water Content Management, submitted to the International Groundwater Symposium "Bridging the Gap between Measurements and Modeling in Heterogeneous Media", to be held at LBNL in Berkeley, CA, 2002.

Hubbard, S. and Y. Rubin, Ground penetrating radar: Development of a Vineyard Management Tool, International Symposium on Integrated Water Resources Management, April 9-12, Davis, CA, 2000.

Training Accomplishments

Katherine Grote, Ph.D. Candidate, Dept. of Civil and Environmental Engineering, UCB
Michael Kowalsky, Ph.D. Candidate, Dept. of Civil and Environmental Engineering, UCB
Wing Yee Wu, Undergraduate, Dept. of Civil and Environmental Engineering, UCB
Tawat Anantanavanich, Masters student, Dept. of Civil and Environmental Engineering, UCB.

Additional Funding

The funding provided by WRC was used to perform the initial experiments needed to test our concepts. Results from the WRC funded experiments were used to request funding from other agencies for extended analysis. We have recently been awarded two grants to perform extended research of the concepts initially funded by WRC:

USDA. $250,000 over 3 years. Large-Scale Monitoring of Soil Water Content using GPR Techniques.

NSF. $281,000 over 3 years. Field-Scale soil moisture monitoring using non-invasive techniques: investigating the link between GPR and remote sensing data.

Hydrodynamics of Shallow Water Habitats in the Sacramento-San Joaquin Delta

Mark Stacey
Civil and Environmental Engineering
UC Berkeley

In the first year of this project, we have focused on developing modeling tools to be used in the analysis of the dynamics of shallow water habitats. Specifically, we are emphasizing the exchange of materials (salinity, contaminants, nutrients, etc.) between shallow water regions of the Sacramento-San Joaquin Delta and the adjoining channels. This exchange is critical to the evolution of the shallow water ecosystem, since they rely on these exchanges to deliver critical scalars into the shallows. An animation program allows us to visualize the three-dimensional structure of the flows under consideration

...modeling tools to be used in the analysis of the dynamics of shallow water habitats (are being developed to examine)... exchange between the shallows and the channels... with a goal of understanding what factors govern the transport of materials between the shallow water habitats of the (Sacramento-San Joaquin) Delta and the adjoining channels.

We have begun the analysis of an idealized channel-shallow system – a straight channel with adjoining shallow water habitat where the details of the bathymetry at the connection between the channel and the shallows can be varied. The process studies examine how the geometric structure of the channel-shallow systems effect exchange between the channels and the shallow water habitats. The three-dimensional modeling activity is examining the details of the tidally-driven exchange, and is targeting the development of more general relationships which can be used in the management of the shallow water habitats. To be specific, the idealized models are examining the following types of connections: (1) an isolated, scoured opening; (2) an isolated, breached levee; (3) a series of levee breaches; and (4) a broad opening with a more gradual transition from channel to shallows. The three-dimensional simulation of each of these cases is being interpreted in the context of a simpler, analytic formulation of the exchange flow, so that the results can be easily generalized and applied to real physical systems.

In year 2, the application of these modeling results to three real systems will be examined. They are Sherman Lake, a channel with a broad, open connection to a shallow-water habitat and Mildred Lake, which is connected to the surrounding channels through an isolated, scoured opening, Little Franks Tract and Franks Tract, which are typified by a series of levee breaches. The exchange between the shallows and the channels for these three cases – each typified by very different

Keywords

Sacramento-San Joaquin Delta
Shallow-water habitats
Channel-shallow exchanges
Hydrodynamic modeling

connection morphologies – will be analyzed with a goal of understanding what factors govern the transport of materials between the shallow water habitats of the Delta and the adjoining channels.

Training Accomplishments

Seungjin Baek, prospective Ph.D. student

Additional Funding

I currently have a proposal prending with CALFED to study the three-dimensional structure of the hydrodynamics of the Delta. This proposal is a joint proposal with the USGS-Sacramento District Office and Stanford University. This proposal would fund continued modeling activity and associated observations which focus on the dynamics of shallow-channel exchanges in the Delta.

Hydrodynamic Design in Coastal Wetland Restoration: Topography Optimization and Stability Assessment by Adjoint Sensitivity Method

Brett F. Sanders
Civil and Environmental Engineering
UC Irvine

Promoted by conservation-banking practices initiated in 1995, wetland restoration and enhancement projects have emerged in southern California as the primary means to mitigate the impact of coastal development. Successful enhancement and restoration designs hinge on a reliable prediction of physical processes including flow, circulation, and transport of nutrients, salinity, sediments, and pollutants. An inadequate prediction may cause a design to fail. Talbert Marsh in Huntington Beach serves as an excellent example. It was constructed in 1990, but by 1991 the marsh had yet to achieve the intertidal zone of the design. By 1995, longshore sediment-transport led to a partial blocking of the Marsh outlet, sedimentation lead to 4-6 feet of silt on the marsh bottom, and the expected level of diversity had not materialized.

A novel approach used in parameter identification and hydrodynamic control applications is being developmed and tested as a new paradigm for computer aided coastal wetland design.

Hydrodynamic models, when properly utilized, may reliably predict circulation in complex estuarine systems that determine depth of inundation, salinity, and velocity regimes—information that is important to wetland planners, ecologists, and biologists. However, the challenge in the numerical modeling process is to properly assess the stability of a design. The Talbert Marsh experience clearly elucidates the consequences of a poor stability assessment. Assessing the stability of a wetland design however is an empirical and interpretative process because of the primitive understanding of the suspension, bed load transport, suspended load transport, and deposition of sediments that limit the ability of models to simulate, let alone predict, these processes for the wide range of particle class sizes present in estuarine systems. To avoid inconsistent designs that lead to wetland failures, a systematic design process that is less reliant on interpretive skills is needed.

A novel approach used in parameter identification and hydrodynamic control applications is being developed and tested as a new paradigm for computer aided coastal wetland design. The bed elevation as a function of location will be optimized to (i) maximize inter-tidal area, a common indicator of productivity and (ii) achieve a hydrodynamic condition characteristic of self-

Keywords

Fluid flow and mechanics
Mathematical models
Optimization

flushing systems Optimization will be performed using a gradient-based method. To efficiently obtain the necessary gradient vector, an adjoint sensitivity method will be developed for wetland hydrodynamics. The proposed methodology will be tested first on a series of hypothetical wetlands, and second on the Talbert Marsh.

The first year has been directed towards a bathymetric survey to characterize the physical state of the field site. A digital terrain map of the Talbert Marsh was produced from the aerial photographs and elevation measurements. Relevant data on soil properties of the marsh and the neighboring beach have been obtained from the coastal engineer in the County of Orange. In addition, we have developed and are testing a hydrodynamic model for the Talbert Marsh and are ready to use the field date to conduct the system optimization study.

Publications

Sanders, B.F., Non-Reflecting Boundary FluxFunction for Finite Volume Shallow-Water Models, *Advances in Water Resources*. (to appear)

Sanders, B.F. and Bradford, S.F. Finite Volume Model for Shallow Water Flooding and Drying of Arbitrary Topography, *ASCE Journal of Hydraulic Engineering*. (in review)

Training Accomplishments

Jenny Arevalo, B.S. Environmental Engineering
Richard Argall, B.S. Civil Engineering
Irene Pau, B.S. Environmental Engineering
Allyson Chu, M.S. Civil Engineering
H-Y Kang, Ph.D., Civil Engineering

Assessment of the Structure and Function of Natural Hydraulic Jumps

Gregory B. Pasternack
Land, Air and Water Resources
UC Davis

This project will provide the insight into how natural hydraulic jumps function in the river ecosystem and how they can be incorporated into river restoration designs. Significant advances were made in the laboratory as well as in the field to better understand hydraulic jumps and their potential for river restoration.

In the laboratory, a new time domain reflectometry method to measure the air contents in hydraulic jump was developed and tested. This measurement costs only one-tenth of that using the traditional methods. Improvements were made in the laboratory to enhance the River Truss that is used to safely, securely, and precisely insert sensors into violently turbulent flow.

In the field, measurements of local air contents were measured without using the River Truss in five hydraulic jumps occurring along an 8.4 km mixed alluvial- and bedrock-dominated section of the South Fork American River. Two small jumps had mean air contents of ~20%, while a large jump had a mean air content of 42%. Three different hydraulic jumps- one on a tributary of the North Fork American River and two on the upper South Fork American River- have been mapped using the River Truss. The detailed bed and water surface profiles of the jumps are the first of their kind. The profiles reveal so much detail that it will be possible to assess the mechanisms responsible for overall jump structure. Velocity and air content measurements have also been made for the two jumps on the upper South Fork American River, with more flow measurements pending. In the upcoming year, hydraulic jumps with a wide range of bedrock configurations and flow characteristics will be mapped using the newly developed instruments and River Truss.

The detailed bed and water surface profiles of the jumps revealed by field measurements using an improved River Truss are the first of their kind. The profiles reveal so much detail that it will be possible to assess the mechanisms responsible for overall jump structure.

Publications

Vallé, B.L. and Pasternack, G.B. In Press. TDR measurements of hydraulic jump aeration in the South Fork of the American River, CA. Geomorphology.

Training Accomplishments

2 graduate students and 2 undergraduate students. The Water Resources Center "seed" money serves as the foundation of the field and lab work associated with the project. One graduate student,

Keywords

River restoration
Hydraulic jumps
Aerated flow
Mountain streams

Brett Vallé, was able to expand from a M.S. thesis to a Ph.D. dissertation and employ several undergraduates to conduct additional research. The primary applications of current research findings are that time domain reflectometry (TDR) provides fast, accurate, repeatable, and nondestructive *in situ* measurements of turbulent air-water mixtures in streams and that the River Truss is an effective tool for safely mapping dangerous flows. Further, large spatial and temporal variations in natural channels restrict direct application of results from idealized channels (e.g. flumes, weirs, and spillways), so field work using the River Truss is critical to improving the science of river restoration.

Research Category II -- Aquatic Ecosystems

This category encompasses basic observational, analytical and theoretical knowledge about aquatic environments and ecosystems. Research areas of interest include biological, chemical and physical mechanisms that govern the behavior of aquatic ecosystems including work on the classification, transport and impact of contaminants and pollutants. Also included in this category are studies of the use of artificual ecosystems for water reclamation, fundamental investigations related to wetland management, studies of the impact of land use practices on aquatic habitats and reconstruction ecology.

Habitat Features and Aquatic Health: Evaluating California's Stream Bioassessment Procedure in Natural and Artifical Streams in Grazed Eastern Sierra Valley

Kenneth W. Tate
Agronomy and Range Science
UC Davis

Linda K. Vance
University Extension
UC Davis

This project explores a central question in the development and use of macroinvertebrate-based stream bioassessment procedures: to what extent do habitat features, particularly those easily influenced by human activity, correlate with "healthy" aquatic biota? A second, but equally important, question is whether macroinvertebrate-based stream bioassessment procedures designed for citizen monitoring in fact provide any information about water quality and aquatic health beyond what can be obtained using simple chemical parameters and visual stream assessment methods.

We approached these questions by examining macroinvertebrate communities in 15 natural and man made streams flowing through Bridgeport Valley in the eastern Sierra. In 1999, 30 study sites with 3 replications per site (n=90) were established, and stream physical and chemical features were evaluated using standard methods. Teams of observers rated the sites using the Natural Resource Conservation (NRCS) Visual Stream Assessment Procedure, the EPA's Rapid Bioassessment Protocol's Habitat Assessment, and the Proper Functioning Condition method developed by the Bureau of Land Management. Temperature loggers were placed upstream and downstream of each site. Macroinvertebrates were collected in August using methods from the California Department of Fish and Game's Stream Bioassessment Procedure for Citizen Monitors, and bank surveys for fish were conducted.

Preliminary analysis provides insight into the "health" of Bridgeport Valley macroinvertebrate communities. Pooling all data across sites in 1999, we found that 69% of the macroinvertebrates sampled were larval-stage EPT (Ephemeroptera, Plecoptera, & Trichoptera) taxa. EPT taxa, commonly called mayflies, stoneflies, and caddesflies, acquire dissolved oxygen through external gills or by cutaneous respiration and therefore require low sediment levels and adequate oxygen levels. These taxa are very sensitive to water quality impairment by land use, and a high percentage of EPT taxa is indicative of favorable water quality and aquatic habitat conditions. Coleoptera (beetles) made up 15% of the samples, 99% of which were from one family (Elmidae). This family and most Coleoptera acquires oxygen in a similar manner to EPT taxa, but have protective respiratory mechanisms that make them less sensitive to impaired water quality and habitat. A small portion (< 15%) of Coleoptera sampled were adults, which have various strategies of obtaining oxygen that allow

Keywords

Bioassessment
Aquatic biota
Water quality
Riparian
Macroinvertebrate
Eastern Sierra
Aquatic health

them to tolerate lower oxygen levels. In contrast, most larvae from the Diptera family (flies), which represented 16 % of the Bridgeport taxa, can tolerate poor water quality conditions, particularly low oxygen levels. Dominance by Diptera at a site often indicates poor water quality and habitat conditions.

Presentations and Publications

Publication and presentation of the results of this project will occur during the Fall of 2001, once data analysis has been completed. Information from this study will be presented to local natural resources managers and regulators in the Bridgeport area, as well as Statewide, via the UC DANR Rangeland Watershed Workgroup and other venues. Results will be made available Nationally via presentations at professional conferences and peer-reviewed scientific journals.

Training Accomplishments

There is one Ph.D. Candidate and one M.S. Candidate actively involved in the project. They have been trained in both field and laboratory components of the project. Three undergraduate interns have been involved in the project, being trained on the laboratory components of the project. Several UCCE Natural Resources Advisors have also been involved in the project, being trained on field methods.

Additional Funding

Preliminary data collected with WRC funding was critical in allowing us to successfully compete for funding from NASA for a project to utilize remote sensing to evaluate irrigation management on stream "health". *Tate, K.W., L.K. Vance, Z. Wan, P. Gong, G. Biging, and R. Gildersleeve. 1999-2002. Using Remote Sensing to Evaluate the Impacts of Flood Irrigation of Meadows in the East Walker River Basin of California. NASA NRA-98-OES-09. $543,490.*

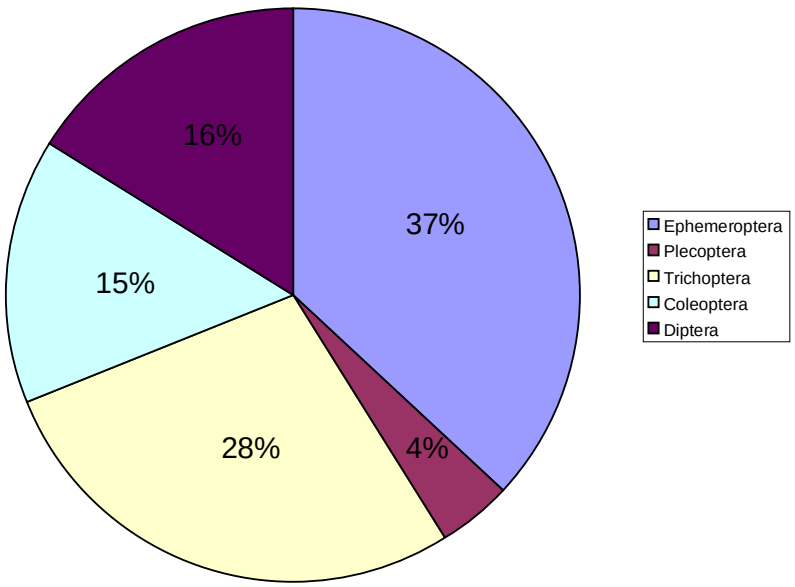


Figure 1. Micro-invertebrate Communities of Bridgeport Valley Streams -- High percentage of Ephemeroptera, Plecoptera, Trichoptera and Coleoptera taxa is indicative of a favorable water quality and aquatic habitat.

How California Fishes Swim Upstream Past Rapids, Waterfalls and Human-Made Barriers

Malcolm S. Gordon
Organismic Biology, Ecology and Evolution
UC Los Angeles

The behaviors, biomechanics and preferences of salmon passing spillways were studied. Jumping capacities, preferences, and methods were determined over a range of spillway heights, gradients and water velocities.

Fishes that swim upstream are of great economic and recreational interest to the people of California. Many stream modifications, such as weirs and dams of different sizes, seriously interfere with reproduction and other important aspects of the life histories of fishes like the Pacific salmon species and steelhead trout. These problems are partially addressed by building fishways, such as fish ladders, to assist fishes in overcoming the man-made obstacles. Most fishways are designed by engineers primarily to ease the passage of salmonids. Little attention has been given in these designs to other ecologically important fishes that share the streams and interact with the salmonids. Even less attention has been given to the behaviors of any of these fishes as they travel upstream past natural rapids and waterfalls as well as through fishways. Fishway design has traditionally been approached from engineering perspectives neglecting the behavior of the animals that are supposed to use the fishway. To design optimal fishways, in terms of the fishes' ability to pass them and the economics of construction, we must better understand the behaviors of the fishes that will use that fishway. One important approach is to experimentally study fishes traveling up artificial rapids and waterfalls in controlled laboratory environments. Understanding how fishes travel up rapids and waterfalls, and why they behave as they do when faced with such obstacles, is essential to the continuing survival of many California inland fishes. The results of this study will aid water resource management in protecting the complex fish assemblages of California watersheds.

The behaviors, biomechanics and preferences of salmon passing spillways were studied. Kokanee, landlocked sockeye salmon (*Oncorhynchus nerka*), were used as model study animals in an adjustable spillway. Experiments were done in a Tahoe Basin stream, Taylor Creek, where these fish migrate during their annual spawning run. Because this type of study had never been done before, a large portion of the project's efforts went towards designing, building and testing the experimental spillway before its assembly at the study site. The spillway was then used to study the biomechanics of fish jumping over the spillway using a high-speed digital video camera. Jumping capacities, preferences, and methods were determined over a range of spillway heights, gradients and water velocities.

Keywords

California inland fishes
Rapids
Waterfalls
Fishway
Behavior
Swim
Leap

Publications

Lauritzen, D.V., Hertel, F. and Gordon, M.S. 2000. Kinematics of Salmon Leaping up Waterfalls. *American Zoologists* 40(6):1098.

Lauritzen, D.V., Hertel, F. and Gordon, M.S. 2000. Biomechanics of Salmonid Fishes Leaping Up Waterfalls. *1st International Symposium on Aqua Bio-Mechanics*. p 19-20.

Professional Presentations

Sockeye Salmon And A Wild Alaskan Waterfall: Possible Lessons For Dam Retrofits. International Congress On The Biology Of Fish In Aberdeen, Scotland (July 2000)

Biomechanics of Salmonid Fishes Leaping up Waterfalls. International Symposium on Aqua Bio-Mechanisms in Honolulu, Hawaii (August 2000)
Kinematics of Salmon Leaping up Waterfalls. Society for Integrative and Comparative Biology Annual Meeting in Chicago, Illinois (January 2001)

Training Accomplishments

Dean V. Lauritzen: graduate student involved in the project

Additional Funding

The results of project W-928 were used as the foundation for a portion of an application for a Santa Monica Bay Restoration Project (SMBRP) funded research program in the amount of $1.1 million. A major focus of this program is the restoration of steelhead trout, *Oncorhychus mykiss*, in the Malibu Creek watershed with emphasis on the effects of Rindge Dam (in Malibu Creek) on the trout. Although funding was not granted for this program due to limited available funds, funding for this project will be pursued again with the SMBRP and with similar funding agencies.

The Influence of Introduced Trout on the Diversity and Structure of Native Aquatic Invertebrate Communities in High Sierran Streams

David B. Herbst
Marine Science Institute
UC Santa Barbara

Scott D. Cooper
Ecology, Evolution and Marine Biology
UC Santa Barbara

The introduction of non-native fish, primarily trout, to Sierran lakes and streams has been linked to declines and losses in over half the 70 species of native amphibians and fish in the Sierra. Because aquatic communities in the High Sierra evolved in the absence of fish predators, these systems may be especially vulnerable to the introduction of fish. Invertebrate communities of streams are often composed of dozens of species with diverse roles in food webs and many stream invertebrates are the primary prey of trout. Despite their diversity, integral ecological roles, and potential for use in ecological assessments, aquatic invertebrates are among the most poorly known of all faunal groups in the Sierra Nevada. This study will provide information on the effects of introduced trout on stream ecosystems, as well as distributional data on stream invertebrates of the central Sierra Nevada.

Using a paired watershed approach, we surveyed 7 stream pairs in the first year of the project (summer 2000). Fish-less streams were contrasted with nearby matched streams containing trout. Our surveys consisted of sampling the benthic invertebrate communities of riffle and pool habitats within defined 150-meter study reaches. Data on the physical stream habitat, water chemistry, algal and detrital food resources, and fish density were also collected to analyze the interrelationships among environmental conditions, trout density, and invertebrate community structure and diversity.

Using a paired watershed approach, we surveyed seven (trout and fishless) stream pairs and found that fishless streams typically contained a greater diversity of total taxa and of large invertebrate predators that those in matched trout streams.

Preliminary laboratory results on invertebrate communities from six of the seven streams surveyed suggested consistent differences between trout and trout-less streams. Fishless streams typically contained a greater diversity of total taxa and of large invertebrate predators than those in matched trout streams. In addition, trout streams contained a greater total percentage of the dipteran family Chironomidae (midges) than fishless streams. Members of this diverse family of small flies often increase in abundance when algae and organic matter become more available as food or

Keywords

Aquatic insects
Benthic invertebrates
Non-native species
Predation
Sierra Nevada
Stream ecosystems
Stream habitat management
Trout
Yosemite National Park

habitat. If trout limit the number, diversity, or feeding activity of invertebrates consuming algae and organic matter, as has been shown in other studies, the population sizes of small, productive midges may increase, as well.

Another approach for examining the influence of trout on Yosemite stream communities was initiated by compared benthic invertebrates above and below waterfalls which acted as natural barriers to fish migration. Little difference was found in the diversity of communities above waterfalls (lacking fish) relative to those below (containing fish), but a large endemic mayfly (*Edmundsius agilis*) was extremely rare and flatworms were reduced when fish were present, and the abundance of midges was again greater in trout than trout-less reaches.

This research project is already influencing public perceptions and understanding of water resources. A research priorities meeting for Yosemite National Park was convened this past spring where 40 scientists identified over 500 topics for study in the Park. The final listing of priorities by participants placed surveys of aquatic reference sites as the top priority for research.

Publications and Professional Presentations

National meeting of the North American Benthological Society (primarily stream ecologists) in LaCrosse, Wisconsin, June 5, 2001. The Role of Exotic Trout in Structuring Stream Invertebrate Communities. E.L. Silldorff, D.B. Herbst, and S.D. Cooper.

Training Accomplishments

Erik Silldorff, a graduate student advised by Scott Cooper, has played an integral role in this project, by gathering background information, conducting field and lab work, and participating in the design of the project. This work will form an integral portion of his doctoral dissertation. Tom Kennedy, the main technician for this project, has also received training through this research and will continue in a Ph.D. program at the University of Alabama in 2002. Several instructors of the Yosemite Institute will receive training in stream monitoring this summer, and five other recently graduated students have received research training through their participation as technicians in the Herbst lab at the Sierra Nevada Aquatic Research Laboratory. Finally, six undergraduate students working in the Cooper laboratory have assisted Erik Silldorff with collecting and processing benthic samples.

Freshwater Mussels in California's North Coastal Streams: Current Status and Geomorphologic Controls

Kurt Cuffey
Geography
UC Berkeley

Freshwater mussels are relatively long-lived and stationary animals (they can live for up to a century), and therefore may be useful as indicators and recorders of changes in the river environment. Such information is provided by measurements of mussel presence and growth rate, population size, density, and age distributions, and isotopic composition of shell material. Moreover, successful establishment of juvenile mussels requires the presence of fish, including salmonids, that are used as hosts during a brief parasitic phase of the mussel development. The presence or absence of juvenile mussels therefore provides evidence for presence or absence of fish. Very little is known about the current status of freshwater mussels in the rivers of California's northern coastal ranges, or about the environmental controls on the distribution of these organisms. This project documents the presence and variability of mussel populations in several rivers in the northern coastal ranges, and assesses what sorts of riverine environment constitute good habitat for them.

We completed an intensive survey of current mussel populations in a 15 km stretch of the South Fork Eel River in and north of the U.C. Angelo Coast Range Reserve. Robust populations (approximately 19,000 individuals found) of two species, *Margaratifera falcata* and *Anodonta californensis*, are found. The distribution of individuals is highly variable along the channel, with most individuals concentrated in a few densely populated sections. The average mussel biomass per length of channel is approximately 0.05 kg/m, but is as high as 1.3 kg/m in the most densely inhabited 50m sections. In contrast to mussels found in rivers elsewhere, here the individuals live exclusively near the channel banks. In addition, mussels are almost completely absent from riffles. Both of these may reflect habitat that is beneficial for surviving high flows during wet winters. Variations in the density of mussel populations also show a preference for certain types of habitat: root

Robust populations (approx. 19,000 individuals found) of two species, *Margaratifera falcata* and *Anodonta californensis*, are found (through)... an intensive survey of current mussel populations in a 15km stretch of the South Fork Eel River in and north of the UC Angelo Coast Range Reserve... (the distribution of) mussels are strongly controlled by patterns of sediment transport and depositition in the channel.

Keywords

Rivers
Ecology
Mussels
Coastal ranges
Eel River

masses of sedges, and crevices in mudstone bedrock are favored compared to sandy or gravelly substrate; this suggests that mussels are strongly controlled by patterns of sediment transport and deposition in the channel.

Training Accomplishments

The project is providing full time funding for one graduate student, Jeanette Howard, who this year successfully advanced to candidacy in the doctoral program.

Examining the Relative Influences of Riparian and Upland Land Cover and Land Use on Instream Habitat: Improved Methods for the Russian River Basin

Nina Maggi Kelly
Environmental Sciences, Policy and Management
UC Berkeley

Adina Merenlender
Hopland Research and Extension Center
UC Berkeley

...instream large woody debris (LWD) plays a major role in creating pool habitat with high-quality shelter values. These pools provide critical refugia for fish, and other aquatic species, during the pronounced dry season of Mediterranean climate systems.

Populations of steelhead trout and coho salmon are listed as threatened throughout California's coastal watersheds. Anadromous fish habitat is strongly influenced by factors operating at a range of scales, including the individual habitat unit, riparian corridor, and overall watershed. Although these multi-scale factors have received extensive study in the conifer-dominated watersheds of the Northwest, much less is known about these factors in the hardwood-dominated watersheds of central and southern California. This research seeks to further our understanding of how fish habitat is created and maintained, and influenced by human land-use activities, in California's Mediterranean-climate, hardwood watersheds.

We are currently conducting extensive field surveys in riparian oak woodlands of streams in the Russian River basin to explore relationships between riparian forest structure, stream geomorphology, instream large woody debris (LWD), and fish habitat. Concurrently, we are collaborating with CDFG in their efforts to convert their extensive data set of stream surveys, from over 50 tributary streams in the Russian River basin, into a spatial data layer in a Geographic Information System (GIS). We will then analyze relationships between stream habitat and land use, land cover (e.g. dominant vegetation type), and topography. LWD has been found to play a major role in creating fish habitat in coniferous watersheds. Although the LWD of hardwood systems tends to be much smaller than that found in mature conifer systems, our initial research indicates that, in some streams, LWD plays a major role in creating pool habitat with high-quality shelter values. These pools provide critical refugia for fish, and other aquatic species, during the pronounced dry season of Mediterranean climate systems.

Keywords

Buffer strips
Riparian
Watershed
Scale
Land use
Salmon habitat
Restoration
GIS
Remote sensing

Publications

Opperman J., and A. Merenlender. *in press*. Passive and active restoration of riparian corridors in the Russian River basin. *in* Proceedings of the California Riparian Habitat and Floodplains Conference, Davis California.

Professional Presentations

Opperman J., and A. Merenlender. Passive and active restoration of riparian corridors in the Russian River basin. California Riparian Habitat and Floodplains Conference, Davis California, March, 2001.

Training Accomplishments

The CWR funding is supporting the PhD research of a graduate student, Jeff Opperman, in the Department of Environmental Science, Policy, and Management, University of California, Berkeley. Three undergraduate students from UC Berkeley have been hired to contribute to this project working as field assistants.

Additional Funding

This grant has been instrumental in procuring additional research funds. The CWR funding for this project has been augmented by a $91,642 grant from the California Department of Fish and Game (CDFG) to study landscape-scale and riparian influences on instream habitat in the Russian River Basin. This grant provides additional funding for field work and GIS analyses, and supports direct collaboration between the PI's of the CWR-funded project, CDFG biologists, and additional UC Berkeley faculty. These collaborations ensure that the results of our research will directly benefit those working to protect, manage, and restore aquatic resources in California.

Conservation Genetics of the Tidewater Goby- *Eucyclogobius newberryi*

David Jacobs
Organismic Biology, Ecology and Evolution
UC Los Angeles

The tidewater goby lives exclusively in California in stream mouth estuaries and lagoons that are often small and are frequently closed to the sea. This small fish is currently federally listed as endangered. Understanding the genetic differentiation in this fish has management implications for state and national parks, military bases and other parties responsible for the streams and estuaries where tidewater gobies occur. Genetic data and analysis should permit appropriate decisions regarding: 1) the protection of individual populations, 2) the appropriate source populations used in restoring extirpated populations, and 3) the genetic consequences of natural and artificial recolonization processes.

The region extending from Salmon Creek to the Salinas Valley is separated from goby populations to the North and South by long stretches of steep shores lacking tidewater goby habitat and is further subdivided by rocky shores and promontories such as Bodega Head and Pt. Reyes. In the last year we sequenced 900 bases of the control region from 160 samples from 11 localities across this region. Analysis of these data using population metrics such as Fst, as well as the presence of fixed differences, confirms that many of these populations are genetically isolated. Only populations that closely spaced along relatively sandy coasts show gene flow [ ]= genetically isolated units, {} = minimal gene flow, - = gene flow. [Salmon Creek] [Estero San Antonio - Estero Americano] [Rodeo Lagoon] [San Gregorio - Los Frjoles] [Baldwin - Moore}{Corcoran} [Aptos] {Bennett Slough].

Tidewater goby populations from Salmon Creek to Salinas Valley are genetically isolated. Only those that are closely spaced along relatively sandy coasts show gene flow. In the Ventura/Malibu region, goby may have experienced a loss of genetic variability through population extirpation.

The Ventura/Malibu region forms a distinct clade in analysis of Mitochondrial sequence documenting isolation from the most closely related fish along the Santa Barbara Coast by the steep stretch of coast near Sea Cliff. There are currently five populations in the region. Following local extinction Malibu was restocked with 52 tidewater gobies from Ventura in 1991. Ormond Dam was natural recolonized in the same time period. Ventura and Santa Clara are the only persisting populations in the region. In July 2001 we

Keywords

Tidewater goby
Estuary
Population genetic
Phylogeography
D-loop
Cytochrome B
Microsatellite
Speciation
Metapopulation

collected tidewater gobies form a population at Topanga that recently colonized this habitat presumably by natural means from the Malibu population. To data we have sequenced 900 bases of the control region from 120 samples from Ventura, Santa Clara, Ormond, and Malibu. The most common haplotype represents over 75% of the data and is most abundant in all samples, the second most common haplotype represents 7.5% of the data and occurs in all samples. All other haplotypes occur less than 3 times and are not present in all samples. Malibu which was stocked with 52 fish appears to be as genetically diverse as the natural long lived and naturally recolonized settings. Overall tidewater gobies in the Ventura/ Malibu region may have experienced a loss of genetic variability through population extirpation.

Publications

Dawson, M. N. J. Staton & D. K. Jacobs. 2001. Phylogeography of the Tidewater Goby, *Eucyclogobius newberryi* (Teleostei, Gobiidae), in Coastal California. Evolution, v. 55 pp. 1167—1179.

Professional Presentations

Cryptic species, cryptic introductions and conservation biology examples from jellyfish, molluscs and fish. *Marine Conservation Biology Institute, 2nd Symposium*. San Francisco State University, June 22-24, 2001

Training Accomplishments

Two Graduate students have been supported by funds from this grant. One of whom Michelle Barlow will receive a Masters Degree based largely on the supported work.

Collaborative Efforts

Our data have been provided in public comment to the fish and U. S. Fish and Wildlife Service in response to proposed changes in the status of the tidewater goby. In addition, we have provided requested data to particular offices of the U. S. Fish and Wildlife Service, to California State Parks and to The Golden Gate and Pt. Reyes National Seashores. At the request of the Fish and Wildlife Service, Tenera and Duke Energy we have used PCR and sequencing to document that putative tidewater goby larvae collected from in front of the Morro Bay Power plant were not tidewater gobies. We have advised Merkel Associates and the U.S Marine Corps on the recolonization of San Mateo Creek with tidewater gobies from San Onofre. We plan to continue communicating with the above parties providing data and analyses as needed for effective management of this endangered taxon.

Additional Funding

In the past year we have received additional funding for the from the Golden Gate National Seashore Association and from North County Transit as mitigation for the extirpation of the San Mateo population of tidewater gobies. We have plans to solicit additional funds from California State Parks and from the estuarine reserves program at NOAA.

Assessing the Response of Degradative Biofilms to Groundwater Pollutants

Jay D. Keasling
Chemical Engineering
UC Berkeley

Bacteria play an important role in the detoxification of polluted groundwater. At sites where intrinsic bioremediation is employed, the clean-up of subsurface contaminants is dependent on the catalytic abilities of indigenous microorganisms. Alternatively, direct application of specific degrader microorganisms to enhance in situ biodegradation is under consideration for treatment of several recalcitrant groundwater pollutants, including methyl tert-butyl ether (MTBE). In recent years there has been a growing appreciation among microbial ecologists that most bacteria in the environment live in communities of microorganisms attached to surfaces, or biofilms. Moreover, it has been recognized that the metabolism of complex organic pollutants often involves the concerted efforts of multi-species bacterial consortia. This shift in our understanding of the structure and function of microbial communities could impact the methods that are used to treat these contaminants and the models that predict rates of groundwater decontamination. Hence, there is a need to understand the interactions between contaminants and bacteria in biofilms and new parameters that more accurately describe the contaminant-bacteria interactions must be defined. Results are summarized as follows:

1. Development of methods to monitor two organisms in a biofilm.

The interactions between a 2-chloroethanol (2-CE) degrading organism, *Pseudomonas* sp. GJ1, and a *p*-cresol degrader, *Pseudomonas putida* DMP1, in laboratory-engineered biofilms were examined. A triple labeling technique compatible with confocal microscopy was used to investigate the influence of toxicant concentrations on biofilm morphology, species distribution, and exopolysaccharide (EPS) production. These two organisms produced distinct biofilms in response to model mixed waste streams comprised of 2-CE and various *p*-cresol concentrations. They maintained a commensal relationship, with DMP1 mitigating the inhibitory effects of *p*-cresol on GJ1. Single species biofilms of GJ1 shifted from loosely

...two organisms (a 2-chloroethanol (2-CE degrading organism, *Pseudomonas* sp. GJ1, and a *p*-cresol degrader, *Pseudomonas putida* DMP1) produced distinct biofilms in response to model mixed waste systems comprised of 2-CE and various *p*-cresol concentrations. They maintained a commensal relationship, with DMP1 mitigating the inhibitory effects of *p*-cresol on GJ1.

Keywords

Biofilm
Biodegradation
Bioremediation
Confocal microscopy
Green fluroescent protein
Computer modeling
Microbial ecology

associated cell clusters connected by EPS to densely-packed structures as *p*-cresol concentrations increased, and biofilm formation was severely inhibited at high *p*-cresol concentrations. In contrast, GJ1 was abundant when associated with DMP1 in a dual species biofilm at all *p*-cresol concentrations, although at high *p*-cresol concentrations it was only present in regions of the biofilm where it was surrounded by DMP1. Additionally, the data indicated that only tower-like cell structures in the GJ1-DMP1 biofilm produced exopolysaccharide, in contrast to the uniform distribution of EPS in the single-species GJ1 biofilm.

2. Dual-species biofilm for pesticide degradation.
We developed a dual species consortium, the simplest case of a multispecies consortium, for biological detoxification of the insecticide parathion. One member of the consortium was responsible for hydrolyzing the parent compound, yielding two metabolites, para-nitrophenol (PNP) and diethylthiophosphate. The second member of the consortium was responsible for mineralizing the stable intermediate PNP, a compound classified as a priority pollutant by the United States Environmental Protection Agency. Kinetic parameters required to characterize the biodegradation of parathion were experimentally determined, and were incorporated into a model describing the activity of the consortium. Additionally, the ability of the consortium to be cultivated as a biofilm was investigated.

3. A mathematical model for biofilm growth and development.
A generalized stochastic simulation was developed to describe biofilm growth and development. The simulation was implemented to study the results of various levels of transport limitation on a growing single species biofilm. In a system with rapid solute diffusion, cells throughout the biofilm grew at their maximum rate, and no solute gradient was formed over the biofilm thickness. In increasingly transport-limited systems, the rapidly-growing fraction of the biofilm population decreased, and was found exclusively at the biofilm-liquid interface. Trans-biofilm growth substrate gradients also deepened with increasing transport limitation. Autoinhibitory biofilm growth was simulated for various rates of microbially-produced inhibitor transport. Inhibitor transport rates affected both the biofilm population dynamics and the resulting biofilm structures. The formation of networks of void spaces in slow-growing regions of the biofilm suggested a possible alternative mechanism for the microscopically-observed evolution of channels in biofilms.

Publications

S. E. Cowan, E. Gilbert, D. Liepmann, and J. D. Keasling. 2000. "Commensal interactions in a dual-species biofilm exposed to mixed organic compounds." *Appl. Environ. Microbiol.* 66:4481-4485.

Eric S. Gilbert, Andrew W. Walker, Jay D. Keasling. 2001. "Degradation of parathion by a mixed-culture biofilm." Submitted.

Natalya Eliashberg, Ivan Chang, Eric S. Gilbert, Jay D. Keasling. 2001. "A generalized stochastic simulation of heterogeneous biofilm growth and development." Submitted.

Natalya Eliashberg, Ivan Chang, Eric S. Gilbert, Jay D. Keasling. 2001. "Population dynamics and species spatial organization in simulated multispecies biofilms." Submitted.

Professional Presentations

S. E Cowan, E. S. Gilbert, A. Khlebnikov and J. D. Keasling. 1999. "Dual labeling with green fluorescent proteins for confocal microscopy." *IAWQ/IWA Conference on Biofilm Systems*, *International Association on Water Quality*, New York, NY.

E. S. Gilbert and J. D. Keasling. 2000. "Degradation of parathion by a dual-species biofilm consortium." *American Society for Microbiology General Meeting*, Los Angeles, CA.

E. S. Gilbert and J. D. Keasling. 2000. "Degradation of parathion by a dual-species biofilm consortium." *American Chemical Society National Meeting*, San Francisco, CA.

E. S. Gilbert and J. D. Keasling. 2000. "Degradation of parathion by a dual-species biofilm consortium." *Biofilms 2000, American Society of Microbiology*, Big Sky, MT.

Training Accomplishments

Eric S. Gilbert, Post-doc
Stacie Cowan, Graduate student
Ivan Chang, Undergraduate student
Maya Lim, Undergraduate student
Niki Rambhia, Undergraduate student
Donald Chua, Undergraduate student
Richard Tsai, Undergraduate student

Bed Texture, Food Web Structure, and Juvenile Salmonid Rearing in North Coast California Rivers

Mary E. Power
Integrative Biology
UC Berkeley

California coastal rivers historically supported large populations of anadromous fishes. These populations have severely declined, in large part due to degradation of spawning and rearing river habitat caused by excessive loading of fine sediments. On the California North Coast, forest management activities, especially road construction, are the most important source of anthropogenically increased sedimentation. Northern Coastal California rivers, such as the South Fork Eel, are particularly vulnerable to land management practices that increase fine sediment loading due to the steep dissected terrain and weak parent material of the drainages.

...growth (of juvenile steelhead trout), both in length and biomass, declines sharply and linearly with increasing concentrations of sand from 0 to 100% embeddedness of the stream substrate.

We are investigating how juvenile steelhead (*Oncorhynchus mykiss*) and the river food webs that support them respond to increasing fine sediment deposition. We are combining manipulative and observational experiments, conducted over two years in the South Fork Eel River at the Angelo Coast Range Reserve. During Year One of this research, we manipulated river bed sediment, establishing six levels of embeddedness with sand on a uniform coarse gravel, pebble and cobble matrix in 2 sq. m flow-through channels set in the river. We studied colonization of channels by benthic insects and algae, their use when upstream and downstream ends were open by free ranging steelhead, and, after channel ends were screened, the feeding and social behavior, growth and survival of two juvenile steelhead enclosed per channel. Among our most striking findings are that growth, both in length and biomass, declines sharply and linearly with increasing concentrations of sand from 0 to 100% embeddedness of the stream substrate. During Year Two, we are examining the abundance and behavior of steelhead trout in riffles and pool tail-outs with differing bed compositions, and will 'reverse engineer' these observed areas, adding fine sediments to free stone areas, and pumping it out of embedded areas, to observe how free-ranging fish respond to this isolated alteration of the single factor of bed composition.

Publications

Power, M.E. Field biology, food web models, and management: Challenges of context and scale. Oikos, in press.

Keywords

Juvenile steelhead growth and behavior
Rearing habit
Fine sediment
Embeddedness
River bed texture
River food web

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/ summer chinook salmon in the Columbia River Basin. Science 290:977-979.

Professional Presentations

"Glimpses of spatial and temporal scales in real food webs" M.E. Power, invited plenary talk for American Society of Limnologists and Oceanographers, Albuquerque, NM, Feb 12, 2001

Training Accomplishments

3 graduate (Ph.D. students) and 4 undergraduate students were involved in the project.

Additional Funding

This proposal helped us acquire background data that supported Prof. Power's participation in an NSF STC (Science and Technology Centers) proposal, focussed on interactions of geomorphology and ecology. The proposal has passed through several reviews, and we are scheduled for a site visit this fall, at the University of Minnesota, where the center would be located. Although laboratory work would be centered at the St. Anthony Falls Hydraulic Lab at Minneapolis-St. Paul, much fo the field work would continue at the Angelo Coast Range Reserve in California,. and would entail collaborations between a number of nationally recognized river engineers, geomorphologists, and ecologists. The proposal at this point has a better than 50% chance of being funded.

An Evaluation of Invasive Species in Lake Tahoe: The Potential Impact of Bass Species on the Lake Ecosystem and Mercury Food Web Transfer

Darrel G. Slotton
Environmental Science and Policy
UC Davis

Introduction of largemouth and smallmouth bass has well-documented predatory impacts on littoral fish communities. Lakes containing bass had depressed densities of littoral prey fish compared to lakes without bass. Non-native black bass species (*Micropterus*) have established populations in the Tahoe Keys, a large wetland that has been converted to marina at the southern end of Lake Tahoe. Largemouth bass have been captured at numerous sites in Lake Tahoe during recent years. Smallmouth bass are expected to establish populations at the lake as well, based on habitat and temperature regimes in Lake Tahoe. We believe that if bass populations establish throughout the lake, they will impact native minnow abundance, depress water clarity, and potentially accumulate larger concentrations of mercury compared with other top predators in the lake.

During this funding period, we have taken a five-pronged approach to determine the impact of introduced bass species on Lake Tahoe. First, using stable isotopes as food web tracers, we have determined an integrated picture of Lake Tahoe's current food web. Second, we have compiled all existing literature, data and scientific models predicting bass growth rates to predict whether these species will indeed be likely to establish permanently within the lake. Preliminary modeling indicates that the temperature and habitat in certain shore zones of Lake Tahoe will allow bass to spawn and grow. Third, this spring seven temperature probes have been placed in various habitats around the lake to gather information to predict future bass viability within certain areas of the lake. Fourth, snorkeling surveys were conducted last summer at the lower ends of tributary streams, embayments, and marinas to see if bass were present in the main body of Lake Tahoe. These locations have been shown to be important nursery grounds for Tahoe's young of the year fishes. Fifth, the analysis of mercury and nutrient concentrations of Lake Tahoe biota has been completed. This provides a measure of contaminant concentrations and predicted transfer into bass if they do indeed establish within Lake Tahoe. If bass feed heavily on crayfish, as they do in other lakes, then these introduced fish species will almost certainly accumulate the highest concentration of mercury in Lake Tahoe's food web.

If bass (become established in Lake Tahoe and) feed heavily on crayfish, as they do in other lakes, then these introduced fish species will almost certainly accumulate the highest concentration of mercury in Lake Tahoe's food web.

Keywords

Invasive species
Bass
Mercury
Lake Tahoe

References

Abrahamson, S.A.A. and C.R. Goldman. 1970. Distribution, density, and the production of the crayfish *Pacifastacus leniusculus* Dana in Lake Tahoe, California-Nevada. Oikos. 21: 83-91.

Evans, D.H. 1969. Life history studies of the Lahontan Redside, *Richardsonius egregiu*, in Lake Tahoe. California Fish and Game. 55(3): 197-212.

Flint, R.W. 1975. Growth in a population of the crayfish *Pacifastacus leniusculus* from a subalpine lacustrine environment. Journal of Fisheries Research Board of Canada. 32: 2433-2440.

Lehr, S. 1999. Summer 1999 preliminary survey. Associate Fishery Biologish. California Department of Fish and Game. Rancho Cordova Office.

Mittlebach, G. G., A.M. Turner, D.J. Hall, J.E. Rettig and C.W. Osenberg. 1995. Perturbation and resilience: A long-term, whole-lake study of predator extinction and reintroduction. 76: 2347-2360.

Schaus, M.H., M.J. Vanni, T.E. Wissing, M.T. Bremigan, J.E. Garvey and R.A. Stein. Nitrogen and phosphorus excretion by detritvorous gizzard shad in a reservoir ecosystem. Limnology and Oceanography. 42: 1386-1397.

Vanni, M.J., J.L. Headworth and M.H. Schaus. 1996. Detritivorous fish as a link among terrestrial, benthic and pelagic ecosystems in an agricultural watershed. 1996 Annual Combined Bulletin of the Ecological Society of America, v. 77; 455.

Vander Zanden, M.J., J.M. Casselman and J.B. Rasmussen. Stable isotope evidence for the food web consequences of species invasions in lakes. Nature. 401: 464-467.

Research Category III -- Water Quality

Research in this category encompasses all factors and processes affecting the quality of the sources of surface and groundwater regardless of the use, and the quality and treatment of water in the transportation and distribution systems. Topics that fall within this category include studies of the sources and the nature of contaminants including those emanating from agricultural and industrial processes, effects of contamination on human health, plant and wildlife, wastewater treatment and reclamation processes, and retrospective evaluations of the effectiveness and impacts of different strategies utilized in California for improving water quality and for preventing water quality degradation.

In-Situ Bioremediation of MTBE-Contaminated Groundwater Using Biobarriers

Marc A. Deshusses
Chemical and Environmental Engineering
UC Riverside

Mark R. Matsumoto
Chemical and Environmental Engineering
UC Riverside

... in-situ trickling filter could reduce the concentration of MTBE in water from 5ppm down to <10ppb. At a constant inlet concentration of 10ppm, the elimination capacity was in the range of 3-4g of MTBE per cubic meter of packing per hour, with removal percentages of 99+%.

The 1990 Clean Air Act Amendments requires that oxygenates be added into gasoline to reduce atmospheric emission of carbon monoxide and ozone by automobiles. Methyl tert-butyl ether (MTBE) is the most commonly used oxygenate. It is estimated that there might be as many as 350,000 leaking underground storage tanks in the U.S. MTBE, if accidentally released, is relatively persistent in the environment. A 1996 U.S. Geological Survey found that MTBE is the second most frequently detected chemical in shallow urban monitoring wells with concentrations ranging from 0.2 ppb to 20 ppb. Clearly, there is a need for cost effective remediation solutions. Bioremediation offers great promise and is widely accepted by the general public. This study concentrated on understanding the kinetics and microbiology fundamentals for MTBE biodegradation from which laboratory and field-scale treatment systems may be designed, and, then, on building and operating laboratory-scale treatment systems to test the efficacy of treating MTBE-contaminated groundwater.

We made significant progress both in the treatment of MTBE in lab-scale systems, and in the microbiology of our MTBE degrading consortium. Four different pure cultures that may be capable of degrading MTBE were isolated. Their 16S rDNA sequences are being determined to identify the cultures and the MTBE degradation kinetic of the isolates is being studied. The isolation of pure cultures represents a major advance. It will enable us to grow large amounts of microorganisms for reactor inoculation and to develop probes to monitor these organisms in the environment.

A new approach of treating contaminated groundwater, *in-situ trickling filter*, was developed and tested in laboratory settings. In this system, the groundwater near the surface where contamination takes place is extracted and re-infiltrated via a trench packed with porous material and MTBE degrading organisms. The system allows for a good control of operating conditions, which is essential for MTBE biodegradation. We found that the in-situ trickling filter could reduce the concentration of MTBE in water from 5 ppm down to <10 ppb. At a constant inlet concentration of 10 ppm, the elimination capacity was in the

Keywords

MTBE
Groundwater
Innovative technologies
Biobarrier
Gasoline

Transport and Fate of Nitrate-Nitrogen in Hetergeneous, Unsaturated Sediments Below the Root Zone

Thomas Harter
Land, Air and Water Resources
UC Davis

Jan W. Hopmans
Land, Air and Water Resources
UC Davis

William R. Horwath
Land, Air and Water Resources
UC Davis

Nitrate is the most widespread contaminant in groundwater causing up to ten times as many well closures in California as all industrial contaminants combined. Most nitrate contamination originates from agricultural non-point sources (fertilizer and confined animal facilities). There is only limited understanding of the fate, transport, distribution, and travel time of nitrate in the deep unsaturated zone, and few data are available for developing strategies to monitor the deep unsaturated zone or for validating current and future groundwater impact assessment methods. This research project will improve our understanding of the link between nitrate date obtained from shallow soil monitoring and groundwater quality in areas with deep groundwater table. Specifically, we are pursuing two objectives:

1. Establish a field research site where the detailed characterization of a deep alluvial unsaturated zone was undertaken with cutting-edge geologic, soil physical, and soil biogeochemical field measurement and laboratory characterization tools.
2. Utilize the field site characterization information for an evaluation of current approaches to modeling and understanding nitrate transport in deep vadose zones; and for developing a conceptual model of nitrate-nitrogen fate and transport in realistically heterogeneous, unsaturated alluvial sediments.

An extensive drilling program was conducted in a nectarine orchard at the Kearney Agricultural Center, Fresno County, where a 12-year fertilization experiment with various fertilizer rates had been completed at the time of drilling. Detailed characterization of the sedimentary environment was obtained in a 50-ft deep cross-section through the orchard. Nitrate analysis was completed on over 600 soil samples for profiling nitrate concentration under each of three different fertilization treatments (0, 100, and 325 lbs/acre). The measured nitrate distribution serves as a validation tool for evaluation of the tools to be developed under objective 2. Laboratory analysis of the soil physical and soil biogeochemical properties of more than 1,000 core samples was completed this funding year. The laboratory data are the basis for understanding and modeling unsaturated water flow and nitrate transport through the soil profile. Laboratory analyses include development and adaptation of new technologies for defining hydraulic conductivity and

Keywords

Nonpoint source pollution
Soil hydraulic properties
Alluvial fans
Nitrate-nitrogen
Stochastic modeling
Geostatistics
Denitrification geochemistry
Unsaturated zone

Feasibility of Using Bioaugmentation with Bacterial Strain PM1 for Bioremediation of MTBE-Contaminated Vadose and Groundwater Environments

Kate M. Scow
Land, Air and Water Resources
UC Davis

Widespread contamination of groundwater by MTBE has triggered the exploration of different technologies for in situ removal of the pollutant. After laboratory studies showed that bacterial strain PM1 is capable of rapid and complete MTBE biodegradation, the organism was used in an *in-situ* bioaugmentation field test at Port Hueneme Naval Base, Oxnard, CA.

... bioremediation, both through innoculation or by stimulating native organisms, shows promise as a technology for cleaning up MTBE-contaminated groundwater.

Two small pilot test plots (A and B) located down gradient from an MTBE contaminated groundwater source were injected with pure oxygen at two depths. One plot (B) was also inoculated with Strain PM1. Within one month of oxygen release, high concentrations of dissolved oxygen were measurable in most shallow and some deep wells. MTBE concentrations upstream from Plots A and B ranged from 1.5 to 6 mg per L. In the downstream wells (and immediately upstream near the oxygen release wells), MTBE concentrations decreased substantially in Plots A and B in shallow depths a few months after the commencement of treatment and remained low for the following year. In the deeper zone, downstream MTBE concentrations decreased substantially in Plot A (uninoculated) but only slightly in Plot B (inoculated). Difficulties with oxygen release to the deeper zone of Plot B, as evidenced by low dissolved oxygen concentrations; was likely responsible for the observed low rates of MTBE removal. Well pump tests indicated that groundwater flow was substantially slower in the shallow than deep zones, and slower in Plot B than A.

A unique aspect of this project is the development of a DNA probing protocol to monitor the survival and movement of Strain PM1, as well as to measure changes in the native microbial community during bioremediation. It quantified strain PM1 in both laboratory and field samples with a detection limit of 2 cells PM1/ ml in pure culture or 180 cells PM1/ml in a bacterial mixture. Increases in the population density of PM1 corresponded to removal of MTBE in microcosms. PM1 strain, ranging in density from 10^2 to 10^5 CFU/ml, was found in both Plot B (inoculated) and Plot A (not inoculated). PM1 densities were higher (up to 1 log order) in Plot B than Plot A, and higher in deep than shallow depths. Detection of PM1 in groundwater samples from outside the field plots suggests PM1-like organisms are naturally

Keywords

MTBE
Bioremediation
Biodegradation
Microorganisms
Groundwater

occurring in MTBE-contaminated groundwater at Port Hueneme. Our findings also suggest that native microorganisms can remove MTBE as effectively as Strain PM1 (in presence of oxygen).

The overall significance of our study is that bioremediation, both through inoculation or by stimulating native organisms, shows promise as a technology for cleaning up MTBE-contaminated groundwater. We have also found a naturally occurring PM1-like organism in MTBE-contaminated groundwater and will next determine its contribution to MTBE degradation.

Publications

Hristova, K. R., C. M. Lutenegger, and K. M. Scow. 2001. Detection and Quantification of MTBE-degrading Strain PM1 by Real-Time TaqMan PCR. Appl. Environ. Microbiol. (in press).

Schwartz, E., and K.M. Scow. 2001. Repeated inoculation as a strategy for the remediation of low concentrations of phenanthrene in soil. Biodegradation (in press).

Bruns, MA; Hanson, JR; Mefford, J; Scow, KM. 2001. Isolate PM1 populations are dominant and novel methyl tert-butyl ether-degrading bacteria in compost biofilter enrichments. Environ. Microbiol. 3:220-225.

Deeb, R.A., H.Y. Hu, J. R. Hanson, K.M. Scow, and L. Alvarez-Cohen. 2000. Substrate interactions in BTEX and MTBE mixtures by an MTBE-degrading isolate. Environ. Sci. Technol. 35:312-317.

Deeb, R.A., K.M. Scow, and L. Alvarez-Cohen. 2000. Aerobic MTBE biodegradation: An examination of past studies, current challenges and future research directions. Biodegradation 11:171-186.

Scow, K.M., E. Schwartz, M.Johnson, and J.L. Macalady. 2000. Measurement of microbial diversity. In: Encylopedia of Biodiversity. (in press).

Scow, K.M. 1999. Soil microbiology. In: Encyclopedia of Microbiology. Academic Press (in press).

Schwartz, E., S.V. Trinh, and K.M. Scow. 2000. Measuring growth of a phenanthrene degrading bacterial inoculum in soil with a quantitative competitive polymerase chain reaction method. FEMS Microb. Ecol. 34:1-7

Macalady, J.L., E. Mack, D. Nelson, and K.M. Scow. 2000. Sediment microbial community structure and mercury methylation in mercury-polluted Clear Lake, CA. Appl. Environ. Microbiol. 66:1479-1488.

Fitzgerald, G., K.M. Scow, and J. Hill. 2000. Fallow season straw and water management effects on methane emissions in California rice. Global Biogeochemical Cycles 14:767-776.

Calderon, F.J., L.E. Jackson, K.M. Scow, and D.E. Rolston. 2000. Microbial responses to simulated tillage in cultivated and uncultivated soils. Soil Biol. Biochem. 32:1547-1559.

El-Farhan, Y., K.M. Scow, and D.E. Rolston. 2000. Kinetics of trichloroethylene cometabolism and toluene biodegradation: model application to soil batch experiments. J. Environ. Qual. 29:778-786.

Presentations

Bioremediation of MTBE through Bioaugmentation at Port Hueneme Naval Facility. Invited talk at the Sixth International Symposium of In Situ and On-Site Bioremediation, San Diego, 6/4/01

Molecular Characterization of MTBE-Degrading

Isolate, Strain PM1. Poster at the Sixth International Symposium of In Situ and On-Site Bioremediation, San Diego, 6/4/01

Bioremediation of the MTBE at Port Hueneme. Invited talk at Port Hueneme Advisory Committee. 3/19/01.

Biodegradation of the Fuel Additive, MTBE, in Groundwater. Invited talk at the University of California, Riverside. 5/31/01

Microbial Ecology of MTBE Biodegradation. Invited talk at the Ecology Graduate Group Odyssey, Tahoe City, CA. 9/18/00.

Training Accomplishments

This project has provided support (direct funding and indirect) for: 1 postdoctoral fellow (Hristova), 3 graduate students at UCD (Smith, Smith, Gandhi) and 6 undergraduate students (Watanabe, Scott, Smith, Adamson, Lu, Sugitani).

Collaborative Efforts

A number of collaborations have been supported or initiated by this project. My lab continues to collaborate with Doug Mackay from U. of Waterloo, Canada, in a biostimulation study at Vandenburg Air Force Base and Prof Mackay provides advice on hydrological issues at Port Hueneme. We are also collaborating with Mike Hyman at NC State on MTBE metabolism and with Rula Deeb (Lisa Alvarez-Cohen's lab at UC Berkeley) on BTEX interactions with MTBE biodegradation.

Enhancing the Utility of an In Vitro Digestive Fluid Extraction as a Management Tool for Contaminated Aquatic Sediments

Donald P. Weston
Integrative Biology
UC Berkeley

Contaminants in sediments are customarily extracted from the samples by a strong organic solvent or strong acid for chemical analysis. The quantification of contaminant levels achieved in this manner may not be biologically meaningful for assessing the environmental risks posed by those sediments. Traditional extraction methods can over-estimate the amount of contaminant that would be available to an organism, as much of what is chemically extractable may not be extractable in the chemical matrix of seawater or the digestive tract of an animal that ingests those sediments. We are developing an extraction procedure that provides a more realistic estimate of the fraction of contaminant that an organism would find bio-available. Briefly, digestive fluid is removed from the gut of a deposit-feeding organism (typically a polychaete worm), and the sediment of concern is incubated in vitro in this digestive fluid. The fraction of contaminant solubilized in the fluid is taken as an upper limit on the amount of contaminant that would be available to the organism during gut passage. The technique holds great promise as a means to assess the ecological risk of contaminated sediments, and provide a measure of bio-available contaminant rather than the total contaminant that is presently quantified. Results should be of great interest to state and federal resource management agencies and all parties with a need to evaluate the risks of contaminated sediment.

In the second year, the *in vitro* digestive fluid solubilization approach is applied to a wider range of toxicants to test whether its outcomes accurately reflect differences in contaminant bioavailability across diverse sediment types. While our past work has been largely with polynuclear aromatic hydrocarbons, we are now testing the approach with organophosphate pesticides (chlorpyrifos), organochlorine pesticides (dieldrin), and industrial organochlorine compounds (PCB). We are spiking 8 diverse sediments from throughout the central California coast and estuaries with these compounds and measuring how readily the contaminants are taken up from the sediments by a deposit-feeding worm, *Nereis succinea*. We are doing digestive fluid extractions in parallel with the worm bioaccumulation tests in order to establish whether bioavailability, as measured by digestive fluid extraction, varies among these sediments in a manner comparable to bioaccumulation by the worm.

...the *in vitro* digestive fluid solubilization approach is applied to a wider range of toxicants to test whether its outcomes accurately reflect differences in contaminant bioavailability across diverse sediment types.

Keywords

Risk assessment
Bioavailability
Sediments

Publications

A publication using the data of year 1 experiments is now in preparation and will be submitted soon. Two additional recent papers on the digestive fluid extraction approach, but not specifically funded by WRC, are:

Chen, Z., L.M. Mayer, C. Quetel, O.F.X. Donard, R.F.L. Self, P.A. Jumars and D.P. Weston. 2000. High concentrations of complexed metals in the guts of deposit feeders. Limnology and Oceanography 45:1358-1367.

Mayer, L.M., D.P. Weston, and M.J. Bock. (in press). Benzo-a-pyrene and zinc solubilization by digestive fluids of benthic invertebrates - a cross-phyletic study. Environmental Toxicology and Chemistry.

Professional Presentations

In the past year presentations on this research have been given at:

Society for Environmental Toxicology and Chemistry, Nashville, TN

University of California, Riverside, CA

U.S. Army Corps of Engineers, Vicksburg, MS

Wichita State University, Wichita, KS

San Francisco Estuary Institute, Richmond, CA

Toxics and Monitoring Focus Groups of the Sacramento River Watershed Program, Sacramento, CA

Environmental Sciences class, UC Berkeley, Berkeley, CA

CALFED Science Conference, Sacramento, CA

Training Accomplishments

A post-doctoral researcher, Jonas Gunnarsson, has been supported by the project in the past year.

Additional Funding

The U.S. Army Corps of Engineers (COE) is interested in the digestive fluid extraction technique for evaluation of dredged material. We have recently begun a collaborative project with them, with award of a $137,000 grant to UC Berkeley. Supplemental funding is anticipated in each of the next two years, with the total award likely to be approximately $500,000.

Landscape Level Controls on Nitrate-Nitrogen in Forested and Chaparral Catchments of Southern California

Thomas Meixner
Environmental Sciences
UC Riverside

The mountains of southern California receive amongst the highest rates of N deposition in the world (~40 kg ha^{-1} yr^{-1}) and as a result stream water NO_3^- concentrations in smog-impacted summer-dry montane ecosystems in the Los Angeles Air Basin are the highest for natural catchments in North America. The problems of localized nutrient enrichment in the mountains surrounding the Los Angeles metropolitan area point to the future of forests and other ecosystem types near urbanizing areas in the western United States, as emissions of NO_x and NH_3 increase with urban expansion.

The terrestrial ecosystems in the semiarid climate, in general, have limited capacity to process and retain chronic inputs of N. Available data indicates that stream flow from watersheds under heavier influences of the smog generated in Los Angeles have higher NO_3^- concentrations than those that are farther away. However, the NO_3^- concentrations of stream flows through the Devil Canyon catchment in the western San Bernardino Mountains, 100 km east of Los Angeles, are extremely variable. Although N deposition should be similar throughout the Devil Canyon watershed, NO_3^- concentrations vary by several orders of magnitude among the sampling sites. The spatially varied distribution of NO_3^- in stream flow provides a unique opportunity to determine the dynamics of biogeochemical and hydrologic processes that exert the greatest control on NO_3^- export from semiarid forested catchments with elevated N deposition.

We conducted detailed water quality sampling at 9 streams in the Devil Canyon watershed. First, we observed that NO_3^- and dissolved organic carbon (DOC) concentrations of water increase as the stream flow increases. In a couple of the smaller streams, there is a noticeable first "flush" of NO_3^- at the onset of the winter rainy season and then it is followed by a drop in NO_3^- as stream flow continues at a level higher than the summer and fall low flows. The increase in NO_3^- with stream flow in the larger streams may also indicate a flushing process. However, we do not observe a decrease in NO_3^- concentrations as the rainy season progresses indicating that a flushing process

... decoupling of the impact of N deposition on terrestrial and aquatic systems in Mediterranean climates... (is caused by) the asynchrony between when atnospheric disposition occurs (summer), the time period of maximum soil NO_3 availability and leaching (winter), and the time of maximum plant N demand (spring).

Keywords

Water quality
Basin hydrology
Atmospheric deposition
Biogeochemical processes of nitrogen
San Bernardino Mountains

is not responsible for the increases of NO_3^- in the larger streams. Second, the strong correlation of DOC and NO_3^- concentrations may indicate a denitrification control on NO_3^- input to streams. The concept of a denitrification control on stream nitrate and DOC concentrations is further bolstered by results of longitudinal surveys and mass balance analyses that indicating plant uptake and denitrification in the riparian zone, rather than a mass dilution process, are responsible for the decline in NO_3^- concentrations. Third, perennial streams have high NO_3^- concentrations while ephemeral streams do not. This difference points to groundwater as the source of the high levels of NO_3^- we observe in the perennial streams. Furthermore the evidence indicates a decoupling of the impact of N deposition on terrestrial and aquatic systems in Mediterranean climates. The primary reason for the decoupling involves the asynchrony between when atmospheric deposition occurs (summer), the time period of maximum soil NO_3^- availability and leaching (winter), and the time of maximum plant N demand (spring).

Our results also have important implications for wildlife managers and water resources agencies as they respond to increases in atmospheric deposition. For wildlife managers these results indicate that the streams with the best habitat, those with large and consistent flows, are those most likely to be impacted by the effects of N deposition. For water resource managers the results indicate that the times when they are most likely to get water for recharge or for filling reservoirs, periods of high flow, are also the periods which are expected to have the highest nitrate concentrations indicating less of a chance to use waters draining deposition impacted watersheds to dilute groundwater impacted by historic agricultural groundwater contamination.

Publications

Meixner, T., E. B. Allen, K Tonnessen, M. Fenn and M. Poth, Atmospheric Nitrogen Deposition: Implications for Park Managers, Submitted to Park Science, 2001

Presentations

Meixner, T., M. Fenn and M. Poth 2001. Controls on N Deposition Impacts in Semi-Arid Catchements. *EOS, Transactions, American Geophysical Union*, 82(20), S140-141, 2001. Paper was presented in Boston, Massachusetts at the spring meeting of the American Geophysical Union, on May 28, 2001.

Allen, E.B., A. G. Sirulnik, L. Egerton-Warburton, S. N. Kee, A. Bytnerowicz, P. E. Padgett, P. J. Temple, M. E. Fenn, M. A. Poth and T. Meixner. In press. Air Pollution and Vegetation Change in Southern California Shrublands. Proceedings of the Symposium on "Planning for Biodiversity: Bringing Research and Management Together" Feb. 29-Mar. 3, 2000 USDA Forest Service Pacific Southwest Research Station, Riverside, California.

Training

One graduate student, Jeff McGovern and two undergraduate students, Megan Robinson and Bridgette Valeron were supported off of this grant. Jeff is working on the biogeochemical processes occurring in the riparian zone of the watershed and particularly surface water groundwater interactions that affect water quality. Jeff is a graduate student in Chemical and Environmental Engineering and will graduate 2 years from now. Megan has been working on nutrient budgets for the watersheds we are monitoring in addition to overseeing and analyzing results from longitudinal surveys. Bridgette has been aiding in field work and analyzing stream samples for DOC.

Additional Funding

I was awarded an NSF CAREER award on the topic "Evaluation of Biogeochemical Watershed

Models: How Do We Know When A Model is Wrong?" ($250,000 over 5 years). One component of this award was to develop a watershed biogeochemistry research group at UC-Riverside. The WRC support showed that I was on my way to establishing such a group at UCR. This fall my forest service collaborators and I intend to submit a proposal to the USDA to follow up on the work we have been conducting in Devil Canyon on a broader basis. It is doubtful that any of the data collected or the insight it provides into watershed biogeochemistry in semi-arid systems could have been made without the WRC funding.

Development of a Rapid, Sensitive and Quantitative Method to Detect Infective Hepatitis A Virus in Water

Marylynn V. Yates
Environmental Sciences
UC Riverside

Wilfred Chen
Chemical and Environmental Engineering
UC Riverside

Microorganisms are responsible for more than 90% of the reported waterborne disease outbreaks in the United States. However, in 50% of the outbreaks, no causative agent is identified due to limitations in our ability to isolate and detect viruses in water samples. Historically, contaminated ground water has been the source of one-half of the reported outbreaks; in recent years, that fraction has risen to more than two-thirds. The most frequently reported cause of contamination in these outbreaks is domestic sewage from septic tanks, leaking sewer lines, cesspools, etc. As a result of the continuing waterborne disease outbreaks, and the growing fraction of them associated with consumption of ground water, the USEPA is finalizing a regulation, the Ground Water Rule, to minimize the risk of acquiring a microbial illness from ground water. This regulation will require all public water systems that use ground water as a source to assess the potential for fecal contamination of the water. The lack of standardized methods that can be routinely performed to detect and quantify infective hepatitis A viruses has limited our ability to measure the occurrence of these viruses in drinking water and other environmental samples. Thus, it is not possible to assess the risk of hepatitis A virus infection through exposure to ground water that is impacted by artificial recharge with reclaimed wastewater.

A two-step (molecular beacon-based) reverse transcription polymerase chain reaction (RT-PCR assay was developed... and experiments were conducted to confirm that the entire process did, indeed, detect hepatitis A viruses.

The goal of this study is to develop a molecular beacon-based reverse transcription polymerase chain reaction (RT-PCR) assay for the detection of hepatitis A virus. The initial efforts were centered on the selection of primers and the design of molecular beacons. A primer set was developed in order to amplify a highly conserved region of the VP3 capsid region of the hepatitis A virus. A molecular beacon was designed to complementarily target the internal region of the PCR amplicon (the product of the PCR amplification). A two-step RT-PCR assay was developed for the detection of hepatitis A virus, and experiments were conducted to confirm that the entire process did, indeed, detect hepatitis A viruses.

There are other viruses that can be amplified using the same RT-PCR protocol. These include enteroviruses (i.e., polioviruses, coxsackieviruses,

Keywords

Drinking water
Groundwater
Recycled water
Artificial recharge
Hepatitis A virus
Pathogens
Viruses
Microbiology
Monitoring
Measurement methods

and echoviruses), which are also commonly found in contaminated water and are known to cause diseases such as aseptic meningitis, myocarditis, and encephalitis. Two such viruses are Echovirus 11 and Coxsackie virus B6. To investigate whether the molecular beacon would detect these two viruses (and therefore lack the degree of specificity required), RT-PCR assays were conducted with Echovirus 11 and Coxsackie virus B6 as the test viruses. The results of our experiments demonstrated that the molecular beacon is specific to only hepatitis A virus, as no increase in fluorescence was detected with either Echo or Coxsackie virus as the test viruses. More importantly, even though amplicons were detected with the Echovirus 11 and Coxsackie virus B6 using visualization on agarose gels (the standard method for detection of PCR product), they were not detected by the molecular beacon, again confirming its superior specificity.

Training Accomplishments

Oymon Leong, M.S. student

Tunable Immunosorbents for the Remediation of Atrazine- and Simazine-Contaminated Water

Wilfred Chen
Chemical and Environmental Engineering
UC Riverside

Ashok Mulchandani
Chemical and Environmental Engineering
UC Riverside

Construction and Characteristics of elastin78-scAb Fusion Protein Expression Vectors

Atrizine, and simazine are the most commonly used herbicides in the U.S. and, upon application, they frequently find their way to the groundwater underlying agricultural production areas. Current treatment methods often are inadequate in reducing their concentrations in the treated water to levels below the required regulatory limits. The antibody-based absorbent is an emerging technology with the potential for removing pollutants from dilute waste streams. Antibodies are produced by human and animals to ensure that the vast majority of the foreign antigens can be bound and removed. Interactions between the antigen and antibody are highly specific with affinity in the range of 10^{11} M^{-1}. It is possible, using genetic engineering technology, to specifically tailor these immunosorbents with desired properties that can be used to selectively remove pollutants in the water. Ideally, the antibodies of the immunosorbents are free in aqueous solution for the reaction while still being able to separate and recover them from water afterwards. The purpose of this project is to develop soluble-insoluble phase tunable immunosorbents for atrizine and simazine.

Our goal in the first year was to construct the tunable immunosorbents with high affinity and specificity for atrazine. Elastin protein-based polymers are structurally similar to the repeating elastrometric peptide sequence of the mammalian protein, elastin and exhibit the thermal reversible soluble-insoluble transition. We constructed the immunosorbent using the synthetic gene encoding for the elastin domain with 78 repeats and fused it to the end of the antibody gene encoding specific for the herbicide atrazine to create an elastin-scAb fusion protein expression vector. The product was subjected to several repeated heat and cold cycle and, except in the first cycle, the immunosorbent, elastin78-scAb, recycled completely. Its functionality in absorbing atrizine was demonstrated.

We constructed the immunosorbent using the synthetic gene encoding for the elastin domain with 78 repeats and fused it to the end of the antibody gene encoding specific for the herbicide atrazine to create an elastin-scAb fusion protein expression vector.

Training Accomplishments

A second year Ph.D. student in Environmental Toxicology, Jae-Young Kim, is currently supported by this grant.

Keywords

Antibodies
Detection
Elastin
Atrazine
Simazine

Publications

Jan Kostal, Ashok Mulchandani, and Wilfred Chen, Tunable Biopolymers for Heavy Metal Removal, *Marcomolecules*, 34, 2257-2261, 2001.

Table 1. *The functionality of the anti-atrazine scAb portion of the elastin78-scAb fusion was demonstrated by ELISA using atrazine-HRP conjugates. A significantly higher absorbance was obtained with the elastin-scAb as compared to the blank.*

Sample	Blank	Elastin78-scAb
A490	0.007	0.063

Application of Acoustic Pressure Waves in Aquifer Remediation and Mobilization of Entrapped Organic Liquids

Constantinos V. Chrysikopoulos
Chemical and Environmental Engineering
UC Irvine

Non-aqueous phase liquids (NAPL) are common contaminants of groundwater. Most NAPLs found in the groundwater are carcinogenic necessitating their removal to protect drinking water standards and the environment. The primary method of remediating NAPL contamination of the aquifer is by continuously pumping the contaminated water out for treatment, until the NAPL concentration of the aquifer becomes acceptable. Among the NAPLs, the denser and more viscose than water types of NAPLs, DNAPL, are even more difficult to be removed by the "pump and treat" technique. They have a tendency to resist the flow of water and sink to deeper portions of groundwater aquifers, because of differences in density and viscosity between water and DNAPLs. It has been theorized that acoustic waves enhance the solubility and, thus, mobility of DNAPLs in the subsurface environment. This hypothesis needs to be conformed before any commitment to field-testing. This Project evaluates potential of applying acoustic wave to enhance the mobility of DNAPLs in aquifer during the pump and treat operation by developing a laboratory device to study the influence of acoustic wave on the transport of DNAPLs in the saturated porous media.

This project evaluates potential of applying acoustic wave to enhance the mobility of DNAPLs in aquifer, during pump and treat operation, by developing a laboratory device to study the influence of acoustic wave on the transport of DNAPLs in the saturated porous media.

A specially designed acoustic reservoir attached to a packed column has been designed and constructed (Figure 1). It has yielded highly quantifiable results. During the first year, experiments were developed to test the effect of acoustic waves propagating through saturated porous media on the mass transfer and the resulting dissolved phase transport of DNAPLs and mobility of DNAPL blobs in saturated porous media. Initial experimental results with this apparatus, using bromide as a tracer, have shown mean break through time of the non-reactive tracer had increased by >8% over a range of frequencies applied (Figure 2). The experiments will be repeated with DNAPLs in which the break through of DNAPLs be tracked by subsequent analysis of the solutes in water using gas chromatography. In addition, A tow dimensional micro-channel model is under construction to test the mobility of DNAPL blob on saturated porous media.

Keywords

Acoustic waves
Remediation
Organic Liquids
Pump
Treat

When completed, results of this project are expected to enhance our understanding on the responsiveness of DNAPLs to physical intervention by the acoustic wave. If the test results are positive, it will expedite the deployment of field testing of this methodology. This technique has the potential to reduce the costs of remediating contaminated aquifer by significantly reducing the time required for pump and treat.

Student Training

Funds for this research have partially supported one PhD student, Mr. Eric T. Vogler, who is conducting this research for his dissertation. Over the past year, several different experimental designs and acoustic sources have been examined in order to obtain results that can then be used to describe the physics of acoustic remediation enhancement.

Additional Funding

Due to the relative complex nature of the problem being investigated, it not likely that additional funding may be obtained. Through the seed funds from WRC, we will be able to establish appropriate experimental designs and obtain preliminary results from which a expanded proposal will be submitted to the National Science Foundation for consideration.

Figure 1. Experimental design of a packed column connected to an acoustic reservoir with pressure transducer as an acoustic source.

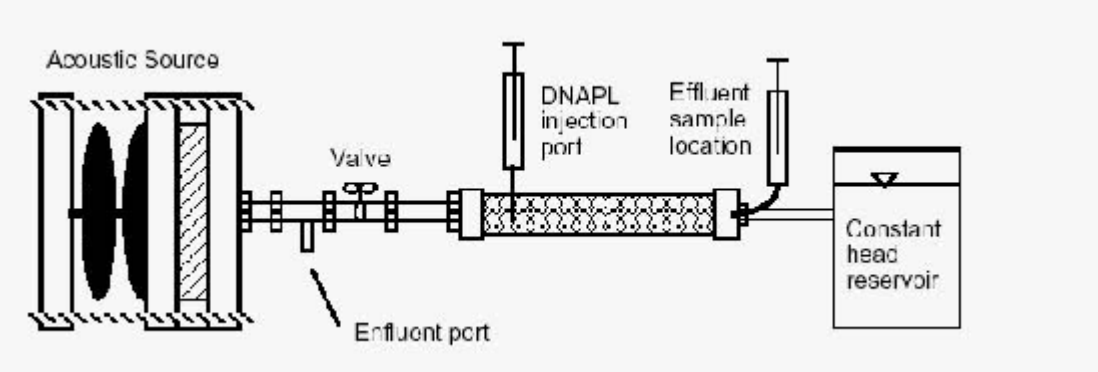
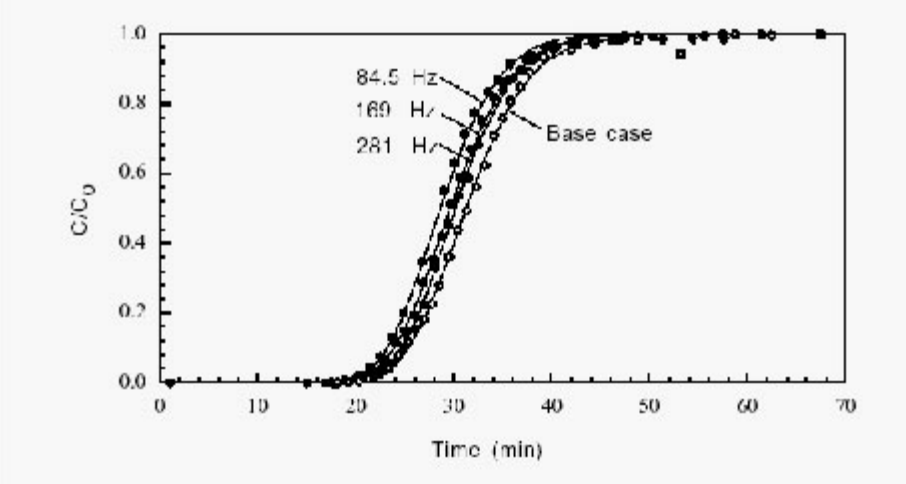


Figure 2. Bromide tracer breakthrough curves, indicating that there is faster transport in the presence of acoustic waves (solid circles) compared to the case of no acoustic waves (open circles). Solid lines represent best fits provided by nonlinear lease squares.



Is Urban Runoff a Source of Human Pathogenic Viruses to Recreational Beach Waters?

Sunny Jiang
Environmental Analysis and Design
UC Irvine

More than 100 million people worldwide visit Southern California beaches and coastal areas annually to sunbath, surf, swim and scuba dive. The 1999 closures of Huntington Beach in Orange County, due to bacterial contamination, during the peak of the summer tourist season created far reaching repercussions to tourism and local economy. The follow up investigations showed that there were multiple natural and urban sources that might have contributed to the presence of bacterial and viral contaminants in the coastal waters. The goal of the study is to understand the source of human viral contamination in southern California waterways. During the first year, we sampled 11 rivers and creeks which empty into the Pacific Ocean along the Southern California coast. In each river, fecal bacterial indicators in the water were determined at two locations, up- and down-stream of the urban area, respectively. The fecal coliform density in eight of the water samples exceeded the water quality requirements of Lake and Streams Recreational standard for body contact recreational activities. Using a polymerase chain reaction (PCR) method, human viruses were detected in 8 of 11 rivers and creeks sampled. The preliminary results indicate that coastal rivers and creeks can be sources of human viral contamination to recreational beach waters. The extent of the contamination is likely to be associated with the volume of urban runoff due to rain/storm events. To understand the seasonal dynamics of viral input from rivers and creeks to coastal waters, a seasonal study of water quality at the mouths of three major urban rivers was conducted over a six-month period covering both dry and wet weather conditions. Significant increases in fecal indicators were associated with rain events. Human viruses were also detected more frequently during the wet season. Further statistical analysis of these data may provide insights into the relationship between urban runoff and the viral quality of coastal waters.

The fecal coliform density in eight of the water samples exceeded the water quality requirements of Lake and Streams Recreational standard for body contact recreational activities... human viruses were detected in the water of eight out of the eleven rivers and creeks sampled.

Publications

A manuscript entitled: "*Urban Runoff are Sources of Human Pathogenic Viruses to Recreational Beach Water*" is currently in preparation. We plan to submit this manuscript to the Journal "*Applied and Environmental Microbiology*".

Keywords

Viruses
Urban runoff
Bacteriophage

Professional Presentations
This project was presented at the following professional conferences by invitation:

Pacific Rim Shellfish Conference. San Diego, California. April 4-6, 2001

Ballona Wetland Foundation Conference. Los Angeles, California. May 17-18, 2001

101st annual meeting of American Society for Microbiology. Orlando, Florida. May 20-24, 2001
82nd annual Meeting of American Association for the Advancement of Science Pacific Division, Irvine, California, June 17-20, 2001

Training Accomplishments: This project has supported 9 undergraduate students' senior research projects. They are:

Miyiki Fujita, Clifford Tse and Elaine Jacinto: Sampled 11 rivers and creeks along coastal Southern California and determined the abundance of fecal bacterial indicators and F-specific coliphage at all sites. Study period: June 2000 – September 2000.

Joanne Choe, Jennifer Cheng, Desiree Eakin, Amana Rafigue, Dalisa Tran and Kevan Savage: Sampled bi-weekly at the mouth of three rivers and determined the abundance of fecal bacterial indicators. Study period: September 2000 – May 2001.

Additional Funding
A proposal developed based on preliminary results of this project was selected by the Water Environment Research Foundation (WERF). The new grant, which is currently in the contract condition negotiation state with WERF, will support research on development of real-time PCR for quantitative determination of viral loading and assaying for the infectivity of the viral particles using a magnetic capturing method.

Biodegradation of Estrogenic Compounds and Its Enhancement in a Membrane Bioreactor

Slawomir W. Hermanowicz
Civil and Environmental Engineering
UC Berkeley

Synthetic estrogenic compounds are discharged with wastewater into lakes and rivers. Although their concentrations are minute (in parts per trillion range), they have been implicated in adverse environmental impacts especially feminization of aquatic organisms. Natural estrogens (mainly 17β -estradiol and estrone) and their synthetic counterparts (chiefly mestranol and 17α-ethinyl estradiol) are primarily excreted with urine. They are partially removed during typical wastewater treatment but the extent of removal varies from plant to plant and among different estrogenic species. As wastewater is the dominant source of these compounds, the objective of the project is to evaluate kinetics of biodegradation of selected estrogenic compounds and a potential for its intensification in a membrane bioreactor.

Since estrogenic compounds are present in very small concentrations, their detection and quantification is difficult. We are working to apply a bioassay using genetically modified yeasts for characterization of estrogenic activities in wastewater. The yeast with human estrogen receptor have been obtained from researchers in Switzerland (Professor D. Picard, Geneva) and we have been working on modifications of testing protocol for wastewater applications. The results are promising and we are researching factors influencing test efficiency: yeast cell conditions (enzymatic activity), cell density, exposure duration and temperature. Since the estrogen receptor in yeast cells is sensitive also to other synthetic compounds, elimination of extraneous stimuli is a major challenge.

... estrogenic compounds are present in very small concentrations, their detection and quantification is difficult. We are working to apply a bioassay using genetically modified yeasts for characterization of estrogenic activities.

Training Accomplishments

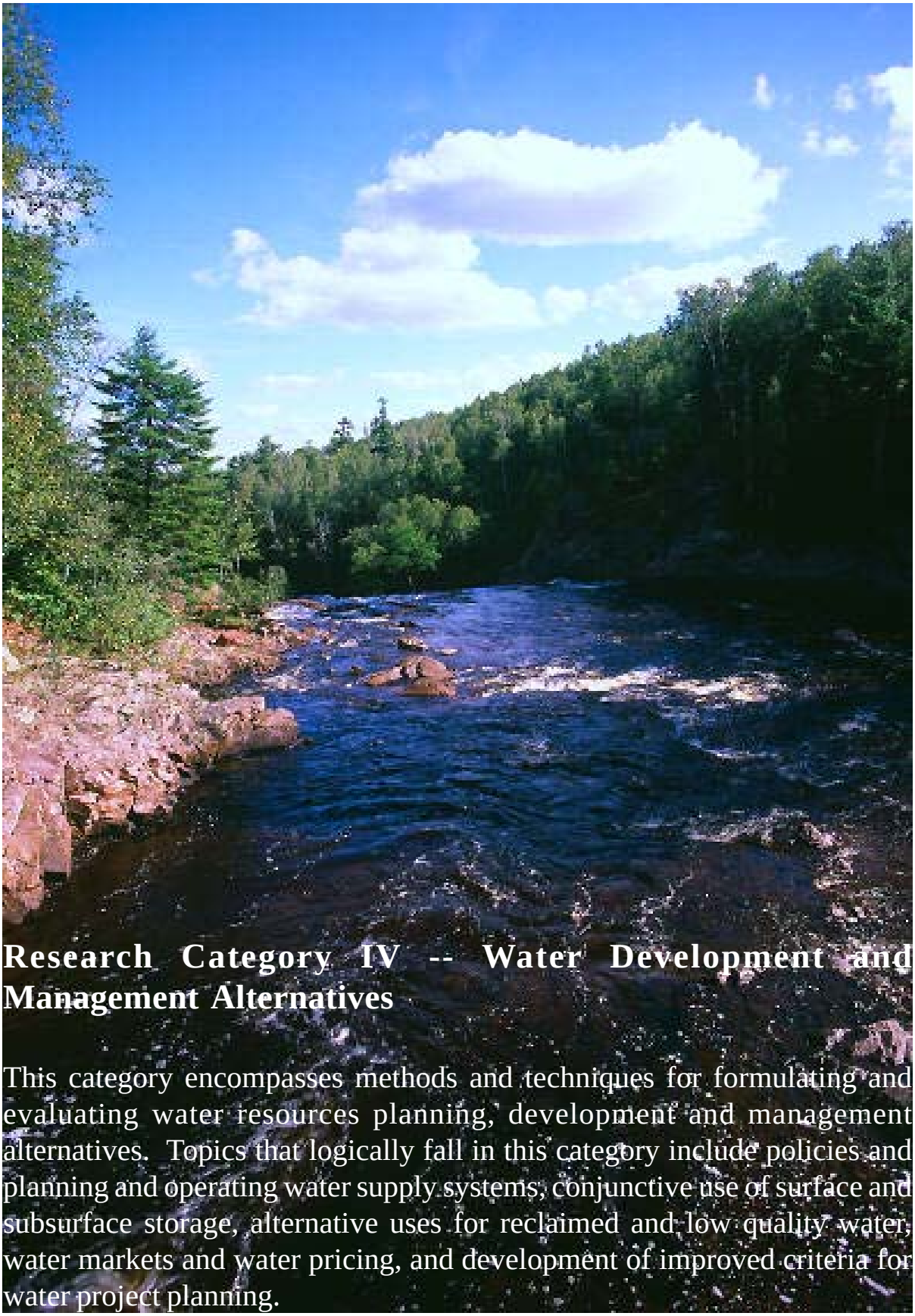
The project partially supports the research of two Ph.D. students (Eleanor Wozei and How Ng). An undergraduate student (Angela Arpke) who participates in the Summer Undergraduate Program in Engineering Research in Berkeley (SUPERB) is also working in our lab.

Additional Funding

A proposal extending the goals of this work was submitted to the Water Environment Research Foundation. Another proposal to be submitted to the National Science Foundation for its Fall 2001 funding cycle is in preparation.

Keywords

Estrogens
Wastewater treatment
Membrane bioreactor



Research Category IV -- Water Development and Management Alternatives

This category encompasses methods and techniques for formulating and evaluating water resources planning, development and management alternatives. Topics that logically fall in this category include policies and planning and operating water supply systems, conjunctive use of surface and subsurface storage, alternative uses for reclaimed and low quality water, water markets and water pricing, and development of improved criteria for water project planning.

Modeling and Optimization of Water Quality in a Large-Scale Regional Water Supply System

William W-G. Yeh
Civil and Environmental Engineering
UC Los Angeles

In a multiple-source regional water distribution system, water agencies often find that it is necessary to blend water from different sources at certain control points in the system to secure the desired water quality downstream of the control points. The objective of the project is to develop a multicommodity flow model for optimizing water distribution in a regional water supply system with blending requirements, and perfect mixing and two-way flow conditions. Blending requirements are treated as constraints and specified at certain control points in the water distribution system.

The multicommodity flow model that incorporates the blending requirements, and perfect mixing and two-way flow conditions is imbedded in a nonlinear optimization model to determine the optimal operating policy for the water distribution system. We first tested and verified the proposed methodology on a simplified, but realistic water distribution system. We then applied our methodology to the water distribution system of the Metropolitan Water District of Southern California (MWD). The perfect mixing and two-way flow conditions create highly nonlinear constraints in the optimization model. To reduce the degree of nonlinearity, a genetic algorithm (GA) is used to search for the optimal flow direction in the undirectional pipe. The solution from GA provides a good initial estimate for the nonlinear optimization model

The multicommodity flow model that incorporates the blending requirements, and perfect mixing and two-way flow conditions is imbedded in a nonlinear optimization model to determine the optimal operating policy for the water distribution system.

Training Accomplishments

Two graduate students were involved in the project.

Keywords

Water supply systems
Water quality
Optimization
Water resources management
Multicommodity flow
Nonlinear programming
Gentic algorithm
Sensitivity analysis

Research Category V -- Water Law, Institutions and Policy

This category encompasses all institutional arrangements (including laws and regulations) that are available or potentially available for developing and managing water resources. Topics which logically fall in this category include institutional arrangements for managing water scarcity, institutional arrangements for managing groundwater (both quantitatively and qualitatively), potential institutional conflicts associated with specific water development and management alternatives and the evolution of water management institutions in California. There is an especially compelling need for policy studies which involve analytical investigations of alternative policies for dealing with all aspects of California's water situation.

An Integrated Modeling Framework for Analyzing Wetlands Policies: Balancing Ecosystems Services and Economic Factors

Marca Weinberg
Environmental Science and Policy
UC Davis

Stephen C. Newbold
Environmental Science and Policy
UC Davis

The purpose of this project is to develop a framework for incorporating considerations of ecosystem services into wetland management. This process consists of two stages: (1) estimating relationships between landscape configuration and the provision of key ecosystem services from wetlands, and (2) incorporating these functions into a spatial optimization model to prioritize locations for the protection and restoration of wetlands. The management of wetlands is important for water policies in general, and in the Central Valley of California in particular, because: they affect water quality by serving as sinks or sources of nutrients and sediments; they are important for flood management by affecting the timing and intensity of flood waves, thereby mitigating flood damages; and they have implications for regional water allocations since healthy wetland systems depend upon adequate water supplies. This project focuses on two key ecosystem services: habitat for waterfowl and other bird species that breed in the Central Valley, and water quality benefits of wetlands.

We have developed models of habitat preferences for a number of birds that breed in the Central Valley. Using data from the North American Breeding Bird Survey, the National Wetlands Inventory, and land use surveys performed by the California Department of Water Resources, we estimated statistical models that describe relationships between the amount and configuration of major land use types and bird abundances. Several species show significant dependence on landscape configuration at the scale modeled. The abundance of breeding mallards and the overall richness of bird species in particular show clear relationships to various land use types, including significantly positive, though decreasing, responses to the area of wetlands. Wetlands management in the Central Valley focuses in part on supplementing waterbird habitat since the region supports a high proportion of waterfowl and shorebirds utilizing the Pacific flyway during fall migration. Our results contribute to this general focus on waterfowl, and add important information about breeding preferences of resident mallards. In addition, the breeding bird richness model provides a more general assessment of the avian habitat support functions provided by wetlands. These two models

... models of habitat preferences for a number of birds that breed in the Central Valley... describe(d) relationships between the amount and configuration of major land use types and bird abundances. Several species shew significan dependence on landscape configuration and the scale model.

Keywords

Wetlands
Optimization
Cost-effectiveness
Ecosystem services

in particular will form the basis of the "habitat benefits" component of the site prioritization model.

We are currently developing models to describe how wetlands can contribute to the enhancement of water quality in the region. These models will be completed in the coming months. To finish the project two additional tasks must be accomplished. First, we will estimate the costs of protection and restoration of wetlands in the study area, and second, we will incorporate all of the elements – habitat, water quality, and costs – into the spatial optimization framework. With the resulting model we can then identify those sites that, if successfully restored to wetlands, should yield the greatest environmental benefits (specifically habitat and water quality benefits) from a limited budget. By the end of the project we will have developed a new tool for wetlands management, and we will have generated a set of general recommendations for the Central Valley of California. Future work will focus on expanding the model to include other ecosystem services, such as flood control benefits of wetlands.

Publications

A conference paper entitled "Integrated modeling for watershed management – Multiple objectives and spatial effects" was presented at the Integrated Decision-Making for Watershed Management Symposium, held on January 7-9, 2001 in Chevy Chase, MD (http://www.conted.vt.edu/watershed.htm). The paper is currently in review for publication in a special issue of the Journal of the American Water Resources Association.

Training Accomplishments

One PhD student has worked on this project: Stephen C. Newbold, UC Davis, Department of Environmental Science and Policy. This project will serve as Newbold's dissertation.

Additional Funding

After receiving Water Resources Center funding this project was selected for funding by EPA under a joint NSF/EPA call for proposals: Decision-making and Valuation for Environmental Policy. EPA has provided supplemental funding for the first two years of the project, and will provide full funding for a third year. The total amount of the award is approximately $125,000.

Multilateral Negotiation: Coalition Formation and California Water Policy

Rachael Goodhue
Agricultural and Resource Economics
UC Davis

Gordon Rausser
Agricultural and Resource Economics
UC Berkeley

Leo Simon
Agricultural and Resource Economics
UC Berkeley

We have completed a general computational framework that may be used to analyze negotiations over water policy. The model allows us to identify compromise solutions that are not apparent ex ante. To date, we have conducted simulations using this general framework that illustrate the value of alliances among stakeholders. We have also shown that alliances may be less advantageous for the stakeholders concerned than the appointment of a single objective representative for the alliance members. That is, stakeholders may do better if they appoint an outside representative rather than ally to represent their interests. Finally, we have examined the importance of the "default solution," in terms of its relative desirability for different stakeholders, and how it interacts with the access probabilities of stakeholders to determine the ultimate compromise solution.

Currently, we are conducting interviews and performing other background research to facilitate the identification of the stakeholders and issues to consider in our analysis of California water policy, specifically the implementation of the CVPIA. Our next objective is to prepare this information in case study form. After doing so, we will evaluate the impacts of including different policy alternatives under consideration by the SWRCB as the default outcome for negotiations. We will consider the effects of altering institutional features on stakeholder welfare; for example, the degree of enforcement of the Endangered Species Act for proposed new listings.

Publications

"A Bargaining Model to Simulate Negotiations Among Water Users." (With Sophie Thoyer, Sylvie Morardet, Patrick Rio, Leo Simon and Gordon Rausser.) *Journal of Artificial Societies and Social Simulation*. 4(2). March, 2001. <http://www.soc.surrey.ac.uk/JASSS/4/2/6.html>

Training Accomplishments

1 graduate student

(In) negotiation over water policy... alliances may be less advantageous for the stakeholders concerned than the appointment of a single objective representative for the alliance members. That is, stakeholders may do better if they appoint an outside representative rather than ally to represent their interest.

Keywords

Water institutions
Negotiations
Stakeholders
Bargaining theory

Negotiating Contentious Claims to Water: Shifting Institutional Dynamics for the Allocation of Water Between the Eel and Russian River Basins

J. Keith Gilless
Environmental Science, Policy and Management
UC Davis

The elaborate legal process that has evolved today disperses decision-making among multiple federal and state agencies. While this can result in friction and inefficiencies in the decision-making process, agency pluralism has also provided new political opportunities for previously ignored claims.

In California, the control of water has shaped the destiny of the land and its inhabitants. Understanding why particular groups achieve, maintain and lose control over a region's water is central to more equitable decisionmaking in water allocation disputes. Negotiations over water are framed by legal regimes that encompass the body of established laws, and the institutions that administer these laws. As the political culture changes however, new regulations and new court interpretations can conflict with established law, and new legal requirements and institutional jurisdictions can encroach on one another. Key debates during the past one hundred years - including how to reconcile public and private water rights, how to balance economic development and in-stream values, and how to resolve the needs and desires of different communities and watersheds - continue to be framed by this evolving and increasingly more complex legal system.

The Potter Valley Hydropower Project (PVP), an interbasin diversion facility in Northern California, is providing an ideal arena to demonstrate how broader changes in legal regimes affect local water allocation decisions. Situated at the pivotal center of two linked rivers, the hydropower project and its diversion of Eel River water into the Russian River was generally supported at the time of its initial construction in 1905, but the continuation of its water diversion is highly contested today. The only legal requirements to establishing a right for power production in 1905 were to post a notice at the point of diversion, record it with the County Recorder, construct the power plant and put the water to beneficial use within a certain period of time. Since the 1913 California Water Commission Act and the 1920 Federal Water Power Act however, the right to appropriate water must be licensed by the state, and power plants on navigable waters are required to be licensed by the federal government. Today decisions about water diversions are affected by multiple legal mandates and agency jurisdictions. These include new environmental regulations and case law that are challenging established state water rights, increased friction between an expanding set of local, state and federal agencies, renewed efforts

Keywords

Water allocation
Interbasin diversion
Legal regimes

by Indian Tribes to access their federal reserved rights to water and their treaty rights to fish, and restrictions on water imported from a different basin.

Today however, new regulations and case law have created a more pluralist process of decision-making involving multiple state and federal agencies and increased public participation. This has altered negotiations over the water diverted from the Eel River. Initially the Federal Energy Regulatory Commission had primary jurisdiction over decisions regarding hydropower and water flow regimes. The passage of the National Environmental Policy Act, the Endangered Species Act, the Clean Water Act, and the Federal Wild and Scenic River Act, along with their state counterparts, as well as modifications to the Federal Power Act, have opened up opportunities both for more public participation and for greater inclusion of environmental values in decision-making. New case law and increased recognition of federal tribal trust responsibilities have provided more opportunities for the Round Valley Tribes' interests to be included. Gaps still remain in implementing the law resulting in reduced opportunities for full participation by all affected parties. However the goal of restoring both rivers and their fisheries, and balancing the needs of all communities affected by the diversion, is likely to remain central in future negotiations.

The elaborate legal process that has evolved today disperses decision-making among multiple federal and state agencies. While this can result in friction and inefficiencies in the decision-making process, agency pluralism has also provided new political opportunities for previously ignored claims. This creates the potential for greater equity in allocative decisions.

Publications

Changing Legal Regimes and the Allocation of Water Between Two Northern California Rivers: A Case Study of the Potter Valley Project and its Interbasin Diversion: Ruth Langridge, author. To Be Submitted.

Training Accomplishments

Ruth Langridge is the Graduate Student Researcher in this project

Associate CE Specialist Thomas Harter
Land, Air and Water Resources
University of California, Davis
9240 Riverbend Avenue
Parlier, CA 93648
Phone: 209-646-6569
Email:

Assistant Research Biologist David B. Herbst
Marine Science Institute
University of California
Santa Barbara, CA 93106-2050
Phone: 760-935-4536
Email: herbst@lifesci.ucsb.edu

Associate Professor Slawomir W. Hermanowicz
Civil and Environmental Engineering
University of California
Berkeley, CA 94720
Phone: 510-642-0151
Email: hermanowicz@ce.berkeley.edu

Professor Richard E Howitt
Agricultural and Resource Economics
University of California
Davis, CA 95616
Phone: 530-752-1521
Email: rehowitt@ucdavis.edu

Assistant Professor David K. Jacobs
Organismal Biology, Ecology and Evolution
621 Charles E. Young Drive South
University of California
Los Angeles, CA 90095-1606
Phone: 310-206-7885
Email: djacobs@ucla.edu

Assistant Professor Sunny C. Jiang
Environmental Analysis and Design
University of California
Irvine, CA 92697-7070
Phone: 949-824-5527
Email: sjiang@uci.edu

Assistant Professor Jay D. Keasling
Chemical Engineering
University of California
Berkeley, CA 94720
Phone: 510-642-4862
Email: keasling@socrates.berkeley.edu

Extension Specialist Nina Maggi Kelly
Environmental Sciences, Policy and Management
151 Hilgard Hall, #3110
University of California
Berkeley, CA 94720-3110
Phone: 510-642-7272
Email: mkelly@nature.berkeley.edu

Professor Xu Liang
Civil and Environmental Engineering
University of California
Berkeley, CA 94720
Phone: 510-642-2648
Email: liang@ce.berkeley.edu

Professor Mark R. Matsumoto
Chemical and Environmental Engineering
Bourns College of Engineering
University of California
Riverside, CA 92521
Phone: 909-787-5318
Email: mark.matsumoto@ucr.edu

Assistant Professor Thomas Meixner
Environmental Sciences
University of California
Riverside, CA 92521
Phone: 909-787-2356
Email: thomas.meixner@ucr.edu

Assistant Professor Gregory B. Pasternack
Land, Air and Water Resources
University of California
Davis, CA 95616
Phone: 530-754-9243
Email: gpast@ucdavis.edu

Keyword Index

UC Center for Water Resources Staff

UC Center for Water Resources
California Water Resources Center
UC Salinity/Drainage Program
Cooperative Extension Water Quality Program
Rubidoux Hall -094
University of California
Riverside, CA 92521

Phone: 909-787-4327
Fax: 909-787-5295
Email: cwres@ucrac1.ucr.edu
Web site: www.waterresources.ucr.edu

Director
Dr. John Letey, Jr.
Email: john.letey@ucr.edu

Management Services Officer
Martha Kennedy
Email: martha.kennedy@ucr.edu

Staff Research Associate
Cindy Dechaine
Email: cindy.dechaine@ucr.edu

Administrative Assistant II
Melanie Carlson
Email: melanie.carlson@ucr.edu