

Readers are encouraged to submit brief articles or ideas for articles. Correspondence, including requests for changes in the mailing list, should be addressed to Randy Brown, California Department of Water Resources, 3251 S Street, Sacramento, CA 95816-7017.

## Is *Carcinus maenas* in San Francisco Bay to Stay?

Joel W. Hedgpeth (with many thanks to Eleanor Uhlinger, Librarian of the Bodega Marine Laboratory for kind and efficient help.)

The late news program was rumbling on one August evening when I became aware that the picture had turned into a swarm of vaguely familiar crabs. They were smallish green fellows, very active, scrambling over a trap of some kind. The familiar voice of Dustin Chivers announced that they were the European green crab, *Carcinus maenas*. The crabs are apparently abundant in the sloughs around Foster City, and they did indeed resemble the color plate in a French book about sea life. The text in that book is hardly reassuring, for in France they are called *le crabe enragé*, the angry crab. They are found everywhere on all kinds of bottom along the Atlantic Coast from Norway south to Gibraltar and in the Mediterranean, where they prefer estuaries. They are "ferocious, voracious and belligerent", and they are especially fond of mussels, which they pry open with one claw and delicately pick the animal out bit by bit. They will eat anything, dead or alive, and will attack people.

In the tidal flats (the Waddensee) of northern Europe, the green crab "is able to control the distribution of mussels, sea urchins and dog whelks." It has emigrated to the western Atlantic and now occurs from Nova Scotia to Virginia, where it is especially fond of soft shell clams (*Mya*). The green crab is also found in Australian waters, apparently introduced about 1960. About

that same time, I had heard of some specimens in Willapa Bay, and I published a warning note about it in the 1962 edition of *Between Pacific Tides* (page 374). Apparently it did not become established there. Hopefully it may eat up the *Potamocorbula* and the *Corbicula* (as adults, the crabs can live in water as low as 4 ‰). But what then?

Most authors consider the Atlantic and Mediterranean forms as races or varieties rather than full species, but the comparatively minor differences are constant and

some authorities consider them to be separate species, called *Carcinus* (or *Carcinides*) *mediterraneus* or *estuarius*. Other than geographical distribution, there seems to be no ecological or behavioral difference between the two races, but these morphological differences may give us some clue to the origin of our new arrivals. The differences are summarized in Table 1, and Figure 1 shows the appearance of specimens from Norway and the Adriatic Sea, emphasized by Roger Tory Petersen bars in the latter.

Table 1  
Differences Between the Female *C. maenas* and *C. mediterraneus*  
From Which Larvae Were Reared  
(from Rice and Ingle, 1975)

<i>C. maenas</i>	<i>C. mediterraneus</i>
Carapace relatively broad (Brighton spec. CL 29.5mm, CW 39.0mm, CW/CL 1.32; Plymouth spec. CL 40.0mm, CW 51.5mm, CW/CL 1.29)	Carapace relatively narrow (CL 27.55mm, CW 34.5mm, CW/CL 1.25)
Carapace dorsal surface relatively rough to touch	Carapace dorsal surface smooth
5th (posterior) pair of antero-lateral teeth directed forward	5th pair of antero-lateral teeth directed more or less outward
Front does not protrude and is not setose	Front protrudes and is setose
Carapace regions not strongly elevated and, when viewed from behind, carapace relatively flat	Carapace regions elevated and carapace vaulted
Outer margin of cheliped carpus not setose	Outer margin of cheliped carpus setose

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Although these small crabs resemble their near relatives of the genus *Cancer*, their zoea are very distinct because *Carcinus* zoea lack the large lateral spines on each side of the carapace (see Figure 2). This should be of assistance in monitoring the spread of *Carcinus maenas* in San Francisco Bay. While the adults may live in low salinities, the larvae need higher salinities. The crabs mate once a year, but the female holds the sperm and may release eggs several

times a year; they produce about 200,000 eggs.

In Europe this is a market species. Adults are held in traps and enclosures until moulting, and sold in the soft shell. They are often served in restaurants. This may be the first useful introduced invertebrate (other than oysters, which the crabs are fond of when they are small enough to be opened). Their immediate impact in this early stage in San Francisco Bay is that they invade bait traps and eat all the bait.

### References

- Breteler, WC, and M Klein. 1983. The shore crab *Carcinus maenas* in Ecology of the Wadder Seas, edited by WJ Wolff, 1:4/119-122.
- Mir, Robert D. 1961. The external morphology of the first zoeal stages of the crabs *Cancer magister* Dana, *Cancer antennarius* Stimpson, and *Cancer anthonyi* Rathbun. Calif. Fish and Game, 47:103-111.
- Rice, AL, and RW Ingle. 1975. The larval development of *Carcinus maenas* (L.) and *C. mediterraneus* Czerniavsky (Crustacea, Brachyura (Portunidae [sic] reared in the laboratory. Bull. Brit. Mus. Nat. Hist., Zool., 28:103-119, 3 pls.
- Riedl, Rupert. 1963. Fauna und Flora der Adria, Paul Valery, Hamburg und Berlin. 640 pp.
- Williams, Austin B. 1984. Shrimps, Lobsters and Crabs of the Eastern United States, Maine to Florida. Smithsonian Institution Press, Washington, DC. *Carcinus maenas*, pp. 356-359.

## Entrapment Zone Workshop

During August, the San Francisco Estuary Project convened a 3-day workshop of about 30 estuarine scientists, engineers, and policy makers to help determine if an entrapment zone standard should be adopted to protect San Francisco Bay. Dr. Jerry Schubel, Director of the Marine Sciences Research Center at the State University of New York (Stony Brook), facilitated the workshop.

The entrapment zone, also called the *turbidity maximum*, is an area in the estuary where the interaction of freshwater inflows, tidal actions, bottom topography, particulate flocculation, and organism behavior, results in the accumulation of particulates. These particles can include small fish as well as phytoplankton and zooplankton. The location of the entrapment zone varies with freshwater flow, and the Environmental Defense Fund (among others) has argued that the location should be positioned near Suisun Bay to maximize its benefit to some estuarine biota.

Discussions among scientists at the workshop quickly indicated there is too much uncertainty regarding entrapment zone benefits to justify setting a standard designed to locate the zone in a specific area at this time. With guidance from Dr. Schubel, the discussion moved to the potential benefits of a bottom salinity standard at various locations from Carquinez Strait to the western Delta. There was also considerable discussion on the desirability of using salinity as a surrogate for flows. To date there has been relatively little effort devoted to salinity requirements of fish and invertebrates in the Sacramento-San Joaquin estuary.

Although potential benefits of a bottom salinity (or flow) standard were qualitatively described, not enough information was available at the workshop to develop a defensible standard. Dr. Schubel recommended, and the majority agreed, that a small technical team attempt to better quantify the benefits and bring the results back to the large group at a meeting now scheduled for December 17, 1991.

Dr. Schubel's summary of the August workshop should be available in late October. Please contact Tim Vendlinski, Estuary Project staff, at 415/744-1989 if you would like a copy.

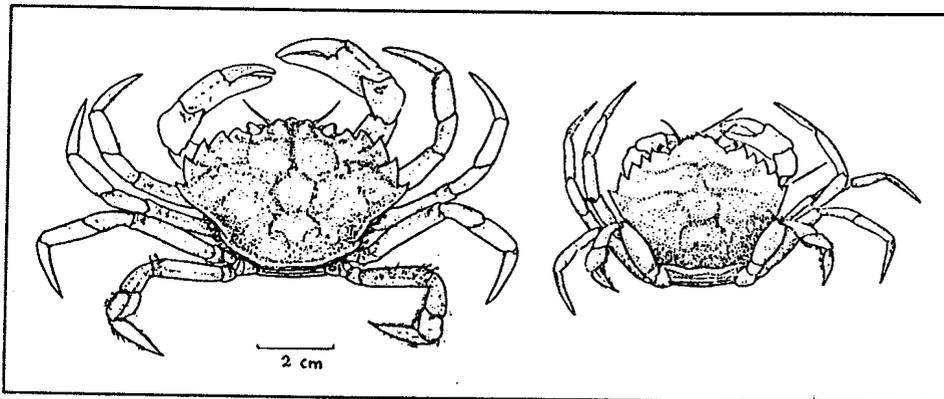


Figure 1  
*Carcinus maenas* from Norway (left; from Williams, 1984) and *Carcinides maenas* from the Adriatic Sea (right; from Riedl, 1963).  
[Common scale for both.]

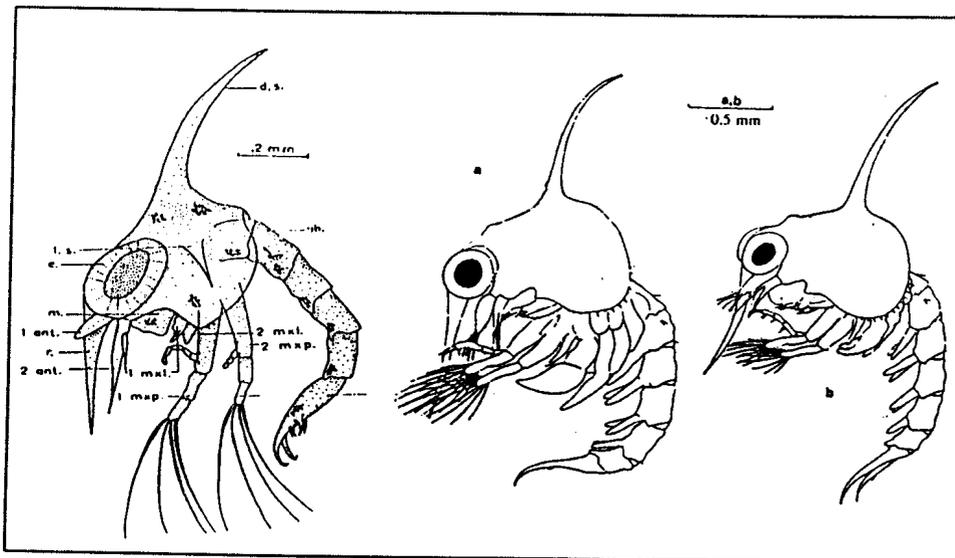


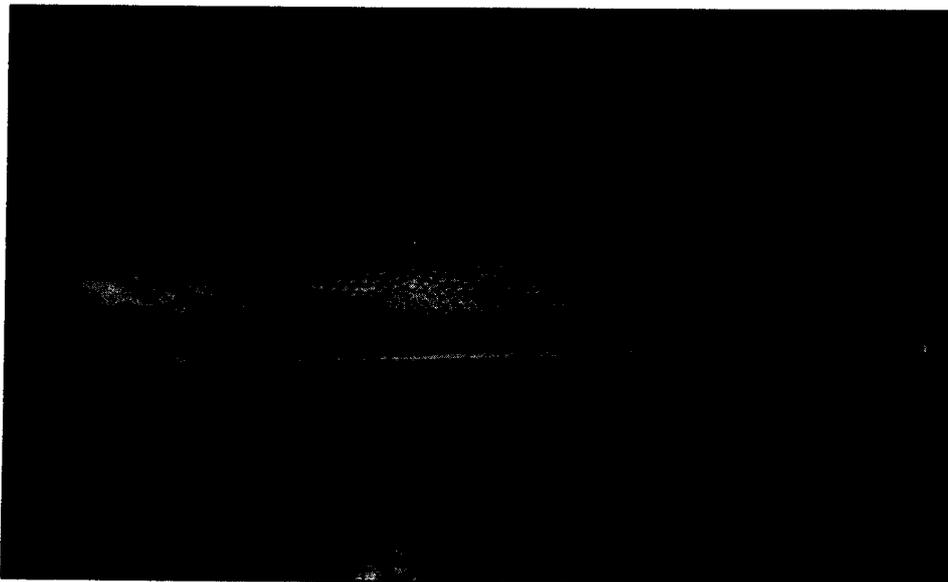
Figure 2  
First Zoea of *Cancer* spp. (left; Mir, 1961) and Zoea Stage IV of *Carcinus maenas* from Plymouth, England, and the Mediterranean (a and b; from Rice and Ingle, 1975)

## Ultimate Predator Removal

For several years there have been concerns that predators are causing large pre-screening losses of juvenile striped bass, Chinook salmon, and other fish in Clifton Court Forebay, a small regulating reservoir at the intake to the California Aqueduct. DFG and DWR have a program to better define the loss rates and to evaluate the impact of predator removal (mainly sub-legal striped bass) on the loss rates. If predator removal is found to be effective in reducing losses, a removal program would become a part of routine operations at the intake. The predators would be collected and returned to locations in the Delta where they would be unlikely to return to the forebay.

As part of this predation study, DWR recently contracted with a commercial fisherman to test the effectiveness of seining for predator removal. On September 17, the 2000-foot-long net captured some striped bass and a 4-foot-9-1/2-inch monster fish. The monster has been tentatively identified as an alligator gar, *Lepisosteus spatula*, a predatory fish native to the southeastern United States. This may be the first (and we hope the last) of this species collected in California. The gar appeared to be well fed and, as Don Stevens of DFG put it, "looked like a long football with teeth." The gar has been frozen and will be mounted.

The seining operation is capturing numerous striped bass and other species. We expect to have a preliminary assessment of the effectiveness of this removal technique in time for the December *Newsletter*.



A 4'9" alligator gar, *Lepisosteus spatula*, trapped in Clifton Court Forebay during DWR's predation study.

## Delta Fish Facilities Program

The Interagency Fish Facilities Technical Committee, DWR's Division of Planning, and former technical committee members Dan Odenweller, Alan Pickard, and Barry Collins have recently been working to develop an expanded fish facilities test program. Pat Coulston, DFG-Stockton, is temporarily taking the lead on biological issues and will assume committee chair in the next few weeks.

The additional studies are being specifically designed to answer questions related to a new intake off the Sacramento River near Hood. Although no one is presently planning to construct this intake, the information

developed would help assess environmental benefits and technical feasibility of such an alternative. Possible study components being considered include evaluation of:

- A sand bed filter as a fish protective device (used in lieu of traditional screens),
- Optimum screen approach velocities for American shad and Delta smelt, and
- The potential for using fan and other pump designs for returning fish to the river.

Agency directors will be asked to consider the first phase of the program at their February meeting.

## Noteworthy —

- USACE and USBR are proposing a California field test to evaluate use of an acoustic signal to guide fish away from diversions. The project is based on recent research in the Midwest in which computers were used to develop sound frequencies that cause fish to avoid power plant intakes. These sounds mimic sounds produced in natural fish communities on the Ohio River. Work thus far indicates sounds of the right frequency mix amplitude and pattern so that fish change their direction. The system was effective in small-scale tests for juvenile steelhead and Chinook salmon. The sound system will probably be tested at Clifton Court Forebay. If it is successful, the system could be used at other locations where physical screening is being considered.
- Dr. Ralph Cheng, USGS-Menlo Park, and a graduate student have developed a software package for graphically displaying water quality and velocity profiles collected by the Interagency Program along San Francisco Bay transects. The software, which runs on an IRIS workstation, allows the user to readily see changes in salinity, temperature, and light transmittance with depth for transects (centerline and near there) from the Golden Gate to above the confluence of the Sacramento and San Joaquin rivers. Since the data were collected at a variety of outflows, the displays help in understanding effects of flow on the estuary. Velocity profiles were collected but are not yet available for display.
- The 1991 ERF meeting in San Francisco is November 10-14. An overview of sessions is given on page 5. If you haven't registered yet, SEND IN THE ENCLOSED FORM TODAY. Also, better make your hotel reservation. Call the Cathedral Hill Hotel: 800/227-4730 (from outside California); 800/622-0855 (from California); 415/776-8200 (local). Be sure to mention that you will be attending the Estuarine Research Federation Conference.

## Delta Smelt Update

Since the last *Newsletter*, there have been several actions and findings related to Delta smelt. Among the more significant are:

- On September 27, USFWS proposed that Delta smelt be listed as "threatened" under provisions of the federal Endangered Species Act.
- On September 25, biologists from DFG, DWR, USBR, UC-Davis, USFWS, and SWRCB met to review a DFG proposal for full-scale Delta smelt studies. The agreed-upon study, which will commence about February 1, 1992, will include greater sampling coverage in time and space (with new gear as appropriate), laboratory spawning and culture, evaluation of losses to Delta islands, and an

examination of the possibility that a closely related species has interbred with Delta smelt. DWR and USBR are jointly funding these studies.

- In mid-September, DFG biologists tested different gear types for capturing juvenile and subadults from the 1991 year class. Preliminary analyses indicated that the Delta smelt population may be 3 to 5 times higher than previously estimated from regular midwater trawl data. More data are needed to confirm this.
- Review of Johnson Wang's draft report, *Early Life Stages and Early Life History of the Delta Smelt ...*, has been completed; the report should be available for distribution in November.

## Coastal Awareness Day — 1991 Participation

The second annual Coastal Awareness Day celebration was held on September 14 at the Jack London Square marina in Oakland. This event is designed to promote understanding of our coastal resources and to consolidate support for their protection. The Nautical Heritage Society organizes the activities, which are actually held at several ports-of-call along the California coastline. The prominent symbol for this program is the State's official tall ship, *Californian*. It joins with several other vessels from various agencies to form an "environmental" fleet

that is on display for public review. The DWR research vessel, *San Carlos*, and the DFG patrol boat, *Albacore*, were included. Practical demonstrations of monitoring techniques, biological sample displays, and a placard presentation were available on the *San Carlos* for a public walk-through tour. Considerable interest and concern about the coastal and bay environments were expressed by the viewers, and there were several lengthy discussions about the involvement of key State agencies in future environmental protection programs.

## Food Chain Group Working Papers

Six working papers produced by members of the Interagency Food Chain Group are now available in a single volume. All of the papers discuss information relevant to food chain processes within the Sacramento-San Joaquin estuary and reflect the authors' current ideas and understanding. Contact Mary Gilleland at 916/323-7203 for a copy. Titles and authors are as follows.

Laboratory Tests of Predation by the Introduced Clam *Potamocorbula* on Larval Stages of the Zooplankters *Eurytemora affinis* and *Pseudodiaptomus* sp.

(Wim Kimmerer, BioSystems Analysis Inc.)

Tests on Effects of Food Limitation on Reproduction in Two Copepod Species Important in the Diet of Larval Striped Bass

(Wim Kimmerer, BioSystems Analysis Inc.)

Observations on Factors Affecting the Young Striped Bass Index in the Sacramento-San Joaquin Estuary

(Jerry Turner, Fisheries Consultant)

Concentration of Food in the Sacramento-San Joaquin Estuary Compared with Other Estuaries Inhabited by Striped Bass

(Lee Miller, DFG)

Analysis of Secular Trends in *Eurytemora affinis* in the Sacramento-San Joaquin Estuary, 1972 to 1988

(Lee Miller, DFG)

Observations on Relationships Between Striped Bass Young-of-the-Year Indexes and Flow Conditions in the Sacramento-San Joaquin Estuary

(Jerry Turner, Fisheries Consultant)

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## Staff Notes

■ Scott Barrow has recently joined the DFG staff in Stockton, filling the position vacated by Dennis McEwan on the Fish Salvage Unit. Scott is a graduate of Humboldt State University.

■ Vicki Vankouwenberg has moved to a job with a private consulting firm. She was working for Marty Kjelson and USFWS in the Stockton office and assisted DFG with secretarial work. Good luck to Vicki.

■ Sally Skelton, a long-time senior lab assistant for the Zooplankton Project in Stockton, has transferred to the Delta Outflow Study. Her new duties will allow her to diversify her activities and spend more time in the field. This is possible now that her son, Sam, is in the first grade.

■ Lisa Lynch has been hired as a lab assistant with the Delta Outflow Study. She comes from a job as a lab assistant in a hospital. Lisa has two young children.

## Western Suisun Marsh Salinity Control Project Scoping Report

The Scoping Report for the proposed Western Suisun Marsh Salinity Control Project EIS/EIR was distributed the first week of September. The report includes information on the proposed project and the environmental impact review and documentation process. It includes comments received and issues raised during the scoping process as well as study plans to address and evaluate issues.

To receive a copy, call Kamyar Guivetchi (DWR) at 916/445-7094. If you have comments or concerns you feel should be considered in the environmental review process, write or call one of the lead agency contacts no later than November 4. The contacts are:

■ Jim Frederick  
US Bureau of Reclamation  
2800 Cottage Way, Room W-2103  
Sacramento, CA 95825  
Phone: 916/978-5134

■ Dwight Russell  
Department of Water Resources  
3251 S Street, Room B-18  
Sacramento, CA 95816-7017  
Phone: 916/323-8888

# Program Overview — Estuarine Research Federation Conference

ROOM	CODE	SESSION TITLE	
International	<b>Plenary</b>	Plenary Session: Reflections on 20 Years of Estuarine Science and a View to the Future	<b>MONDAY</b>
Japanese Pavilion	<b>MO: B</b>	Comparative Cycling of Natural and Contaminant Materials in Estuaries: Overview	
California	<b>MO: C</b>	Disturbance in Seagrasses I: Causes and Patterns	
International	<b>MO: D</b>	1. Water Quality Criteria Development and Environmental Legislation 2. Model Utilization in Estuarine Management	
Cathedral Hill A	<b>MO: E</b>	Striped Bass I: Management and Models, Sampling Methodology, and Contributions to Life History	
Cathedral Hill B	<b>MO: F</b>	Nutrients, Phytoplankton, Microzooplankton, and their Connections	
El Dorado/ Exhibit Hall	<b>POSTER</b>	Distribution, Dynamics and Management of Estuarine Biota	
"	<b>POSTER</b>	Seagrasses	
"	<b>POSTER</b>	San Francisco Bay	
Japanese Pavilion	<b>TU: A</b>	Comparative Cycling of Natural and Contaminant Materials in Estuaries: Trophic Cycling	<b>TUESDAY</b>
California	<b>TU: B</b>	Disturbance in Seagrasses II: Causes and Effects	
International	<b>TU: C</b>	The NSF Land Margin Ecosystem Research Program (LMER)	
Cathedral Hill B	<b>TU: D</b>	Striped Bass II: Environmental Factors Affecting Survival	
Cathedral Hill A	<b>TU: E</b>	A Comparison of Large River Delta Estuaries	
Cathedral Hill B	<b>TU: F</b>	Estuarine Resources, Habitats, and their Utilization by Biota	
Japanese Pavilion	<b>TU: G</b>	Comparative Cycling of Natural and Contaminant Materials in Estuaries: Geochemistry of Trace Contaminants and Nutrients I	
California	<b>TU: H</b>	Ecological Processes in Tropical Estuaries	
Cathedral Hill A	<b>TU: I</b>	Coupled Physical and Biological Processes	
El Dorado/ Exhibit Hall	<b>POSTER</b>	Research Activities and Progress at LMER Sites	
"	<b>POSTER</b>	Minorities in Marine Science Undergraduate Program at Shannon Point Marine Center	
"	<b>POSTER</b>	Ecological Processes in Tropical Estuaries	
"	<b>POSTER</b>	Ecology, Management and Restoration of Coastal Habitats	
"	<b>POSTER</b>	Inputs and Cycling of Natural and Contaminant Materials in Estuaries	
"	<b>POSTER</b>	Effects of Contaminants in Estuaries	
"	<b>POSTER</b>	Sediment Dynamics	
"	<b>POSTER</b>	Approaches to the Assessment and Management of Estuaries	
Japanese Pavilion	<b>WE: A</b>	Comparative Cycling of Natural and Contaminant Materials in Estuaries: Geochemistry of Trace Contaminants and Nutrients II	<b>WEDNESDAY</b>
Cathedral Hill A	<b>WE: B</b>	Coastal Habitat Restoration (I. Submerged Aquatics; II. Saltmarshes)	
Pacific Hts/Calif*	<b>WE: C</b>	Estuarine Fronts and their Implications *Pacific Heights-am & California- pm	
International	<b>WE: D</b>	Estimating the Future of Estuaries	
Cathedral Hill B	<b>WE: E</b>	Long Term Trends in Water Quality and Consequences for Key Living Resources	
California	<b>WE: F</b>	Estuarine Management = Bridging the Gap Between Science and Policy	
Cathedral Hill B	<b>WE: G</b>	Global Change and the Coastal Environment	
International	<b>WE: H</b>	Watershed - Estuary Interactions	
Cathedral Hill B	<b>WE: J</b>	Environmental Health Aspects of Estuarine Research	
Cathedral Hill B	<b>WE: K</b>	Bioaccumulation and Effects of Contaminants in Estuaries	
Japanese Pavilion	<b>TH: A</b>	Comparative Cycling of Natural and Contaminant Materials in Estuaries: Microbial Biogeochemistry	<b>THURSDAY</b>
Cathedral Hill A	<b>TH: B</b>	Fish Recruitment as a Fisheries-Independent Event	
International	<b>TH: C</b>	Federal Coastal Program Initiatives	
Cathedral Hill B	<b>TH: D</b>	Ecology, Biogeochemistry, and Hydrology of Marshes and Submersed Macrophytes	
California	<b>TH: E</b>	Estuarine Sediment Dynamics	
Cathedral Hill A	<b>TH: F</b>	Historical Trends in Contamination of Estuarine and Coastal Sediments	
International	<b>TH: G</b>	Sustainable Development, Science, and Management in Estuaries: Where are We Heading in the Northeast Pacific?	
Cathedral Hill B	<b>TH: H</b>	New Directions in the Experimental Study of Predator-Prey Dynamics	
California	<b>TH: I</b>	Ecology of Large-Scale Disturbance	
International	<b>TH: J</b>	Environmental Monitoring and Assessment Program (EMAP) - Estuaries	
Cathedral Hill B	<b>TH: K</b>	Use of Mesocosms and Microcosms to Investigate Benthic-Pelagic Coupling	

# Unit of the Month

## Compliance Monitoring and Analysis Section, Suisun Marsh Unit and Control Systems Maintenance Unit

DWR shares the responsibility for conducting the monitoring program outlined in the Suisun Marsh Plan of Protection and specified in the Suisun Marsh Monitoring Agreement with DFG and USBR. The purpose of the Plan of Protection is to maintain the brackish water environment of Suisun Marsh, ensure a diverse wetlands habitat, and maximize the production of waterfowl food. The plan also provides for future supplemental water supplies and related physical facilities.

The Suisun Marsh Unit maintains a network of salinity recorders, pond stage recorders, and soil salinity testing sites throughout the marsh. The information is used to determine compliance with salinity standards established by SWRCB, to evaluate the effectiveness of staged physical facilities constructed in the marsh, and to establish correlations between applied water salinities and resulting root zone salinities for key plant species. It is also used to improve water management practices followed by private club owners to sustain preferred habitat.

The complexity of these diverse monitoring programs demands a variety of electronic recording instrumentation, water quality sensing devices, and computerized data processing modules. The Control Systems Unit is responsible for maintenance and calibration of this array of electronic equipment. The staff stays abreast of current technology and evaluates and recommends new instrumentation as it is developed. The unit is also responsible for processing and managing the voluminous file of information produced by the automated, multiparameter, water quality recorder network.

### Our Staff

■ Harlan Proctor, Environmental Program Manager I, is Chief of the Compliance Monitoring and Analysis Section. Harlan is responsible for compliance with the monitoring and reporting requirements of Decision 1485 and the Suisun Marsh Plan of Protection. He has a B.S. in Sanitary Sciences, School of Public Health, U.C. Berkeley.

#### Suisun Marsh Unit

■ Karl Jacobs, Environmental Specialist IV, is Chief of the Suisun Marsh Monitoring Unit. Karl is in charge of data management, analysis and interpretation, and report preparation. He has a B.S. in Chemistry from University of California, San Diego, and an M.S. in Chemistry from California State University, Sacramento.

■ Ruppert (Woody) Hunziker, Land and Water Use Analyst, collects and analyses data and maintain field equipment. Woody is involved with marsh soil classification and water management. He has a B.S. in Soils from College of Agriculture, University of Florida, and an M.S. and Ph.D. in Soil Chemistry and Fertility from Iowa State University.

■ Joseph Nardella, Water Resources Technician II, collects and maintains field data. Joe is also responsible for processing EC and stage recorder tapes. He has a B.S. in Parks and Recreation from California State University, Sacramento.

■ Richard (Dick) Wada, Water Resources Technician II, is responsible for data collection, equipment maintenance, data storage and maintenance. Dick also produces inventory summaries and equipment status reports for the Unit.

■ Kent Scovel, Water Resources Technician II, is responsible for data collection, equipment maintenance, data storage and maintenance. Kent is also responsible for maintaining historical data files.

■ Gregory Woelffer, Student Assistant, assists in maintaining the data management system. Greg also assists in developing basic computer programs for editing data. He is current pursuing a B.A. in Mathematics with an emphasis in Computer Science from California State University, Sacramento.

■ Barbara Mann, Graduate Student Assistant, assists in data collection, equipment maintenance, data storage and management. Barbara helps develop formats and produce graphics for compliance reports. She has a B.S. in Mechanical Engineering from California State University, Sacramento, and is currently pursuing an M.S.

#### Control Systems Maintenance Unit

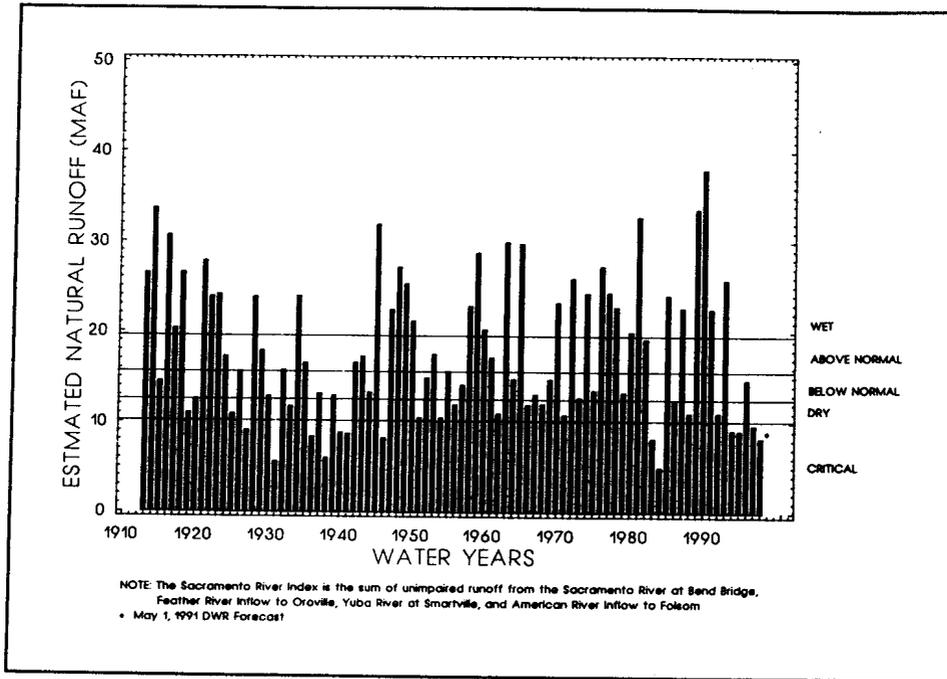
■ Heinrich (Hank) Gebhard, Associate Control Systems Engineer, is the lead person in the Unit. Hank is responsible for operation, repair, and calibration of electronic sensing instrumentation for water quality and meteorological monitoring. He evaluates new equipment and maintains the multiparameter data base. Graduate of Milwaukee Institute of Technology and five years of science research at Cal Tech.

■ Michael Dempsey, Control Systems Technician II, assists in the maintenance and operation of electronic water quality monitoring equipment. Mike is responsible for maintaining field equipment and coordinates the processing and editing of the multiparameter water quality data base.

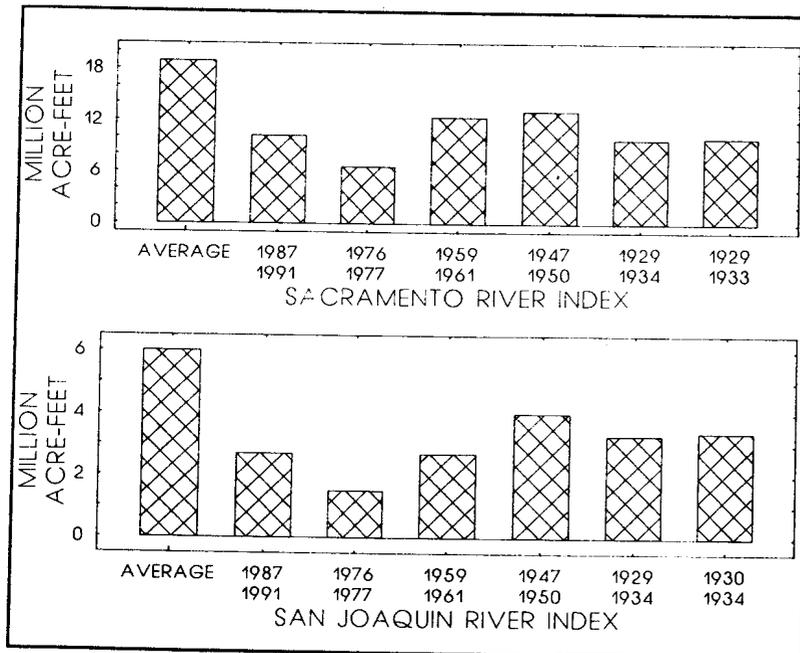
■ Juan Valadez, Control Systems Technician, is responsible for the maintenance of the multiparameter sites and assists in the calibration and repair of the water quality sampling equipment. Juan has a B.A. in Politics from University of California, Santa Cruz.

# Runoff, Drought, and Water Storage

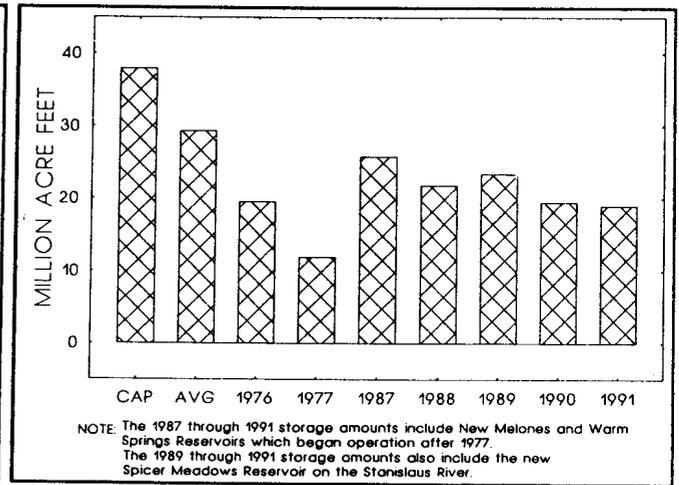
For those interested in runoff, drought, and water storage, the graphs below show data through July 1, 1991. The information was developed by Maurice Roos of DWR's Division of Flood Management. The actual plots were produced by Rory Fagan of the Environmental Studies Branch.



SACRAMENTO RIVER INDEX SINCE 1906



COMPARISON WITH PREVIOUS DROUGHTS



TOTAL STORAGE IN 155 MAJOR CALIFORNIA RESERVOIRS ON JULY 1

Interagency Ecological Studies Program  
*NEWSLETTER*  
3251 S Street  
Sacramento, CA 95816-7017

DEPT OF FISH AND GAME  
ATTN: PERRY HERRGESELL  
4001 NORTH WILSON WAY  
STOCKTON CA 95205

Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary

# *NEWSLETTER*

California Department of Water Resources  
State Water Resources Control Board  
U.S. Bureau of Reclamation

A Cooperative Effort of:

U.S. Army Corps of Engineers

California Department of Fish and Game  
U.S. Fish and Wildlife Service  
U.S. Geological Survey

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