

# Understanding the Environmental Effects of Once Through Cooling

## Research Results Symposium

January 15-16, 2008  
University Club  
University of California, Davis 95616

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**TUESDAY, JANUARY 15, 2008**

8:00 – 9:00 AM	Registration
9:00 – 9:10 AM	<b>Welcome Address</b> – Lara Ferry-Graham (Once through cooling Project Manager at Moss Landing Marine Lab)
9:10 – 9:20 AM	<b>Opening Remarks</b> – Melinda Dorin (Project Manager California Energy Commission PIER Program)
9:20 – 9:50 AM	<b>LIFE HISTORY PARAMETERS OF COMMON NEARSHORE MARINE FISHES</b> – Eric Miller and Charles Mitchell (MBC Applied Environmental Sciences)
9:50 – 10:20 AM	<b>RESEARCH ON DATA AND METHODS FOR ONCE-THROUGH COOLING IMPACT ASSESSMENT</b> – Elizabeth Strange (Stratus Consulting)
10:20 – 10:30 AM	<b>BREAK</b>
10:30 – 11:00 AM	<b>MOLECULAR IDENTIFICATION AND ENUMERATION OF INVERTEBRATE LARVAE POTENTIALLY ENTRAINMENT BY ONCE-THROUGH-COOLING IN ELKHORN SLOUGH, CALIFORNIA</b> – Jonathan Geller (Moss Landing Marine Labs)
11:00 – 11:30 AM	<b>THE ICHTHYOPLANKTON OF KING HARBOR, REDONDO BEACH, CALIFORNIA, 1974–2006</b> – Daniel Pondella (Occidental College, Vantuna Research Group)
11:30 – 12:00 PM	<b>ASSESSING THE FAR-FIELD IMPACT OF ENTRAINMENT ON LARVAL DISTRIBUTIONS AND IMPLICATIONS FOR ESTIMATING THE IMPORTANCE OF ENTRAINMENT ON LARVAL MORTALITY</b> - John Largier (Bodega Marine Lab, University of California Davis)
12:00 – 1:15 PM	<b>LUNCH</b>
1:15 – 1:45 PM	<b>THE WHY, WHEN, AND HOW OF ASSESSING IMPINGEMENT AND ENTRAINMENT IMPACTS</b> – John Steinbeck (Tenera Consulting)
1:45 – 2:15 PM	<b>ECOLOGICAL ISSUES IN SCALING RESTORATION TO OFFSET UNAVOIDABLE IMPINGEMENT AND ENTRAINMENT LOSSES</b> – Elizabeth Strange (Stratus Consulting)
2:15 – 2:45 PM	<b>BRIGHT VIBRATING SCREENS: INCREASING THE DETECTABILITY OF FISH SCREENS</b> – Joe Cech and Timothy Mussen (University of California, Davis)
2:45 – 3:00 PM	<b>BREAK</b>
3:00 – 3:30 PM	Panel discussion with all speakers

## WEDNESDAY, JANUARY 16, 2008

9:00 – 9:10 AM	<b>Welcome Back</b> – Steve Saiz/Dominic Gregorio (State Water Resources Control Board)
9:10 – 9:20 AM	<b>Opening Remarks</b> – TBD (State Water Resources Control Board)
9:20 – 9:40 AM	<b>SUMMARY OF ALTERNATIVE COOLING SYSTEMS ANALYSIS</b> – Tim Havey (Tetra Tech Inc.)
9:40 – 10:00 AM	<b>ISSUES ASSOCIATED WITH RETROFITTING COASTAL POWER PLANTS</b> – John Maulbetsch (Maulbetsch consulting)
10:00 – 10:15 AM	<b>DISCUSSION OF RETROFIT STUDIES</b>
10:15 – 10:30 AM	<b>BREAK</b>
10:30 – 11:00 AM	<b>ELECTRIC RELIABILITY STUDY</b> – Matt Trask
11:00 – 11:20 AM	<b>USING SALT WATER IN COOLING TOWERS</b> – John Maulbetsch (Maulbetsch consulting)
11:30 – 12:00 PM	<b>STATE WATER RESOURCES CONTROL BOARD 316(b) STAFF REPORT</b> – Steve Saiz/Dominic Gregorio (State Water Resources Control Board)
12:00 – 1:00 PM	State Water Resources Control Board Expert Review Panel Discussion
1:00 PM	Closing remarks

## ABSTRACTS

### LIFE HISTORY PARAMETERS OF COMMON NEARSHORE MARINE FISHES

Eric F. Miller, Charles T. Mitchell

MBC Applied Environmental Sciences

Biological parameters from various life history stages were investigated for white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), spotfin croaker (*Roncador stearnsii*), and yellowfin croaker (*Umbrina roncadior*). Early life history parameters, such as age and growth and associated measures such as mortality, were characterized for white croaker, spotfin croaker, and queenfish. Preliminary data suggests strongly differential growth rates based on what portion of the spawning season the individual larvae was spawned. Juvenile/adult age and growth in queenfish and yellowfin croaker was characterized. Yellowfin croaker were found to reach a maximum age of 15 years old with significant differences between the sexes in terms of growth rate, with females outpacing males. Preliminary data for queenfish indicates a maximum age of 12 years. Batch fecundity for spotfin croaker and yellowfin croaker were assessed, with preliminary data suggesting both species display an exponential relationship between size and fecundity, as has been noted for most teleosts. Final data for spotfin croaker indicates batch fecundities range from 35,169 to 640,703 based on the size of the female. Lastly, spawning seasonality for yellowfin croaker was determined via histological analysis. These data indicate a condensed spawning season for yellowfin croaker which begins in June and terminates in August, based on collections made in San Clemente, California.

### RESEARCH ON DATA AND METHODS FOR ONCE-THROUGH COOLING IMPACT ASSESSMENT

Elizabeth M. Strange, P. David Allen II, and David Cacela

Stratus Consulting Inc., Boulder, CO and Washington, DC

This research focused on some of the critical issues related to once through cooling impact assessment. We conducted sensitivity analyses to identify life history data gaps that are the highest priority for future monitoring; modeled life history vulnerability to impingement and entrainment and identified potential indicator species; created electronic databases of life history data; and reviewed approaches for cumulative impact analysis. In this presentation, we will summarize our findings and discuss recommendations.

### MOLECULAR IDENTIFICATION AND ENUMERATION OF INVERTEBRATE LARVAE POTENTIALLY ENTRAINMENT BY ONCE-THROUGH-COOLING IN ELKHORN SLOUGH, CALIFORNIA

Jonathan Geller, Josh Mackie

Moss Landing Marine Laboratories

The goals of this study were to investigate the utility of 1) DNA barcoding methodology for the characterization of marine or estuarine zooplankton communities and 2) quantitative polymerase chain reaction for the enumeration of specific target organisms in natural plankton samples. DNA barcoding was inefficient, requiring individual sorting of larvae, extraction and PCR. PCR success was 50%, which we consider unsatisfactory, and 12-40% of successful amplifications turned out, after sequencing, to be bacterial in origin. Improved primer design might solve low success rate and bacterial contamination problems. However, we believe that looming new technology offer more attractive approaches to whole community analysis, and individual sorting protocols will be obsolete. Specific amplification of *Artemia franciscana* was achieved in background plankton DNA (PDNA) using conventional, end point PCR and quantitative PCR using Syber-Green and Taqman reporter systems. At low background plankton DNA concentration (5 ng/ul), qPCR of a dilution series of *Artemia* DNA showed detection of 0.00001 ng of DNA, and no difference in sensitivity from *Artemia* DNA in water alone. Syber-Green proved to be the most sensitive reporter system. QPCR in higher concentrations of background DNA showed a tendency for PCR inhibition depending on the source of background DNA. Extraction efficiency also varied for different plankton samples, with algae dominated samples showing low DNA yields. We recommend spiking of samples with extraction control organisms. One nauplius was readily detected when added to 20 mg of whole wet plankton, and nauplius abundance could be inferred up to 35 nauplii in such samples. Greater than 35 nauplii, or even one adult, were easily detected but not quantifiable, as the QPCR signal "maxed" out. Thus, analysis of a dilution series of samples will necessary in real field studies to ensure results are within the dynamic range of the chosen detection system. We suggest the next steps in molecular characterization of plankton will be to: 1) use QPCR on actual targets of interest (eg, fished

species such as Dungeness crab, *Cancer magister*, or likely prey of predators of conservation concern (otters) - QPCR is ready for field applications; 2) develop new PCR primers and methods that limit amplification of bacterial DNA; 3) investigate innovations such as such as emulsion PCR or in-gel PCR – two methods for ensuring quantitatively representative amplification for unbiased whole sample analysis. Such sequences could be quantified to produce sequence (=species) frequency distributions using new technology (see 4); and, 4) use massively parallel sequencing technology (MPPS; eg, pyrosequencing). MPPS is a new technology developed for genome sequencing. MPPs can sequence simultaneously 1.6 million 100-200 bp fragments. This would be more than sufficient to sequence all species in a PCR-in-emulsion reaction from whole plankton.

## **THE ICTHYOPLANKTON OF KING HARBOR, REDONDO BEACH, CALIFORNIA, 1974–2006**

**Dan Pondella, Jonathan Williams and Eric Miller**

**Occidental College, Vantuna Research Group**

The Vantuna Research Group has been monitoring the ichthyoplankton of King Harbor, Redondo Beach on a monthly basis continually since 1974. In the southern California bight, this is the only long-term monitoring program of this nearshore larval fish assemblage. The assemblage varies significantly with macro scale environmental changes. Most notably the switch of the Pacific Decadal Oscillation in the late 1970's precipitated a dramatic decline of all larval taxa. During 1980's and 1990's elevated sea surface temperature (SST) was exacerbated by an increased frequency and strength of El Niño Southern Oscillation (ENSO) events, the first of which was the 1982-1984 ENSO at that time the largest on record. Throughout the 1990's SST were at or above the 1982-84 event. Larval fish densities continued to decline significantly throughout the 1990's and were negatively correlated with SST for the major taxa. This study site, which lies in the southeast portion of Santa Monica Bay, is proximate to three coastal generating stations: Redondo Beach, El Segundo and Scattergood. These once-through cooling stations are all undergoing their 316(b) studies. Our current application is to place these studies into the appropriate long-term context and to evaluate the natural variability of this nearshore ecosystem. We will describe the changes in the larval community over this time frame and make a recommendation as to the appropriate sampling frequency for monitoring and evaluating this community.

## **ASSESSING THE FAR-FIELD IMPACT OF ENTRAINMENT ON LARVAL DISTRIBUTIONS AND IMPLICATIONS FOR ESTIMATING THE IMPORTANCE OF ENTRAINMENT ON LARVAL MORTALITY**

**John Largier**

**Bodega Marine Lab, University of California, Davis**

The results of field analyses and modeling is presented and placed in the context of estimating larval mortality due to entrainment by coastal power plants. The aim of the study is to allow for improved methods for estimating the level and importance of this larval mortality under conditions typical of California. Selected data on coastal circulation have been analyzed to determine the typical flow patterns, strengths and variability in the vicinity of coastal power plant intake structures – with attention given to both open-coast and estuarine sites. Typical, idealized flow patterns obtained from this analysis were then used in model estimates of dispersion and entrainment. The interaction of typical larval dispersal patterns with typical power plant intake flow structures has been investigated with a particle-dispersion model, based on observation-based idealized flow fields for open coast and estuarine sites. Key parameters describing larval sources, larval behavior, flow patterns and intake configurations have been varied to determine the primary controls on time dependent near-shore larval distributions and power-plant-intake withdrawal zones. The primary model outputs are the number of larvae entrained versus the number of larvae that can potentially recruit to adult habitat. Finally, the results of the data analysis and dispersion modeling were used to revise the conceptual model and expressions used to quantify proportional larval loss due to entrainment. Attention has been given to the form of the expressions as well as estimates of error, critical input data, and ways to validate existing and newly proposed ways of estimating proportional larval mortality.

## **THE WHY, WHEN, AND HOW OF ASSESSING IMPINGEMENT AND ENTRAINMENT IMPACTS**

**John Steinbeck,**

**Tenera Environmental Inc., San Luis Obispo, CA.**

The information in this presentation is largely taken from a recent CEC report, "Assessing Power Plant Cooling Water Intake System Entrainment Effects" prepared with John Hedgepeth and Dave Mayer from Tenera, Greg Cailliet from Moss Landing Labs, and Peter Raimondi from UC Santa Cruz. Environmental effects of cooling water withdrawal result from the impingement of larger organisms on screens that block material from entering the cooling water system and the entrainment of smaller organisms into and through the system. This presentation focuses on methods for assessing entrainment effects (not impingement), and specifically, entrainment effects on ichthyoplankton. Examples from three studies that differed in the characteristics of the source water body are used in presenting the different modeling approaches for assessing entrainment effects and discussing some of the considerations for the proper design and analysis of CWIS studies.

## **ECOLOGICAL ISSUES IN SCALING RESTORATION TO OFFSET UNAVOIDABLE IMPINGEMENT AND ENTRAINMENT LOSSES**

**Elizabeth M. Strange, P. David Allen II, Dave Mills, and Colleen Kenney**

**Stratus Consulting Inc., Boulder, CO and Washington, DC**

In this research we considered the data and methods available for scaling restoration to offset impingement and entrainment losses that continue to occur even after implementation of the best technology available. A key issue is how to estimate the increase in secondary production that is expected to result from a given restoration action. In this research, we compiled and evaluated available data for use in determining the type, extent and cost of restoration to offset unavoidable losses; conducted expert review of assembled data to reach consensus on parameter values; and performed a detailed analysis of methods for restoration scaling. In this presentation, we will summarize results of these analyses and provide recommendations for future restoration planning.

## **BRIGHT VIBRATING SCREENS: INCREASING THE DETECTABILITY OF FISH SCREENS**

**Joseph J. Cech, Jr., Timothy D. Mussen (presenter)**

**Department of Wildlife, Fish, and Conservation Biology, University of California, Davis**

There are numerous water diversions along California's waterways that can be fatal to resident and migratory fish species that can become entrained in their influent currents. Screens are commonly situated in front of water diversions to prevent fish from being displaced from their habitat, but the screens themselves can be harmful to fish if they contact them severely or repeatedly. This experiment was designed to determine the sensory systems that fish use to recognize and avoid fish screens and to the possibility that vibrating fish screens or strobe lights may be used to reduce the number of times fish will contact screens when in close proximity. We tested the swimming performance of Sacramento splittail (*Pogonichthys macrolepidotus*), steelhead trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*) in a 1-m wide, 1-m deep and 8.5-m long oval-shaped flume. The swimming trials were conducted with the fish confined to a small section of the flume in the area immediately upstream of the screens. Experiments were conducted during both the day and night to test the importance of vision to fish screen avoidance. The fish's swimming performance (including: impingements, screen contacts, swimming locations and other swimming behaviors) was recorded, using incandescent lighting during the day and infrared lighting during the night. A 0.20 g streptomycin sulfate/l bath was used, in some treatment groups, to temporarily disable the fish's lateral line system and to test the direct importance of vibration detection to screen avoidance. Industrial, pneumatic vibrators were attached to the center of the wedge-wire fish screens, allowing the entire screen to vibrate as a unit. Strobe lights were mounted so that they illuminated the screens at a flash rate of 300 flashes/min. The fish contacted the screens less frequently during the day and the streptomycin showed mixed results that were species dependent. Currently we have seen no significant response to the vibrators or strobe lights at these frequencies.

## **CALIFORNIA'S COASTAL POWER PLANTS: COST AND ENGINEERING ANALYSIS OF COOLING SYSTEM RETROFITS**

**Tim Havey**

**Tetra Tech, Inc. Lakewood, Colorado**

This study seeks to build upon model and case study technology analyses that have been used to develop EPA's Phase I and Phase II 316(b) rules in support of the SWRCB's development of a statewide cooling water intake policy. Specifically, the research focuses on site-specific data, to the degree practical, to account for the inherent complexities at an existing facility that often present significant challenges to a particular technology's use. The study's scope is limited to technologies that can achieve a desired reduction of impingement and entrainment impacts (90 percent or greater) without a companion biological analysis, effectively reducing the universe of evaluated technologies to wet cooling towers and, in two cases, cylindrical wedgewire screens. For wet cooling towers, a facility-specific, conceptual design and cost profile is developed using publicly-available and facility-provided data combined with engineering analyses and vendor-provided budgetary quotes. This study establishes a more accurate understanding of the technical and logistical feasibility of wet cooling system retrofits at existing facilities while developing realistic cost estimates. Other potentially limiting factors, such as secondary environmental conflicts (e.g., increased air emissions, altered effluent quality) and local use constraints (noise, building height, or planned development ordinances), are quantified where possible and use to inform the overall system design. The presentation will focus on the criteria used to assess "technical feasibility" while addressing the broader issues that add to a wet cooling system retrofit (e.g., energy penalty, environmental restrictions).

## **ELECTRIC RELIABILITY STUDY**

**Matt Trask**

This presentation will describe preliminary conclusions about the Electric Reliability study, discussing the potential effects on reliability of the Water Resources Control Board's pending decision on once-through cooling.

## **USING SALT WATER IN COOLING TOWERS**

**John Maulbetsch**

**Maulbetsch Consulting**

An alternative to the use of fresh water for cooling tower make-up is the use of high salinity water. The sources may range from the ocean, to estuaries to saline groundwater. Potential issues associated with the choice of saline make-up include effects on tower thermal performance and on the choice of materials of construction, both of which may affect the cost of the tower. In addition, operating and maintenance problems may arise as well as potentially exacerbated environmental problems particularly from the salinity of the drift.

A brief review of the design, performance and cost differences between freshwater and sea/brackish water cooling towers is given. The results of a survey, based on visits to several plants using salt water towers, of operating and maintenance problems, procedures and costs are presented. The issues related to drift from salt water towers is discussed.

## **SPEAKER BIOGRAPHIES**

### **CECH JR., JOSEPH J**

#### **University of California, Davis**

Joseph Cech is the Director of the University of California, Davis Center for Aquatic Biology and Aquaculture. His recent work has focused on California species. He has taught at several universities and served as editor for the *Transactions of the American Fisheries Society*, and *Copeia*. Cech has been the recipient of numerous awards including more recently from the American Fisheries Society and the USDA. He got his B.S. at the University of Wisconsin, Madison in Zoology and his M.A. and Ph.D. at the University of Texas, Austin, in Zoology.

### **DORIN, MELINDA**

#### **California Energy Commission**

Melinda Dorin is a Technical Research Manger with the California Energy Commission's Public Interest Energy Research (PIER) Program – PIER Environmental Area. Dorin is the PIER technical lead for research on reducing the environmental affects of once-through cooling. She has worked for several agencies on endangered fisheries and terrestrial species issues, water rights, and in a regulatory role. She received a B.S. in Ecology from University of California, San Diego.

### **FERRY-GRAHAM, LARA**

#### **Moss Landing Marine Laboratories**

Lara is presently Research Faculty at Moss Landing Marine Laboratories and also Program Director of the CEC/PIER funded Water Intake Structure Environmental Research Program at MLML. She received her BS in Biological Sciences from California Polytechnic State University and her MS in Marine Science from San Francisco State University/Moss Landing Marine Laboratories. She received her PhD in Ecology and Evolutionary Biology from UC Irvine. She completed her postdoctoral studies at the Center for Population Biology at UC Davis. Lara has been at MLML since 2002 and maintains an extramurally-funded research program that includes studies of organismal form and function, habitat use, and anthropogenic impacts on habitat use.

### **GELLER, JOHNATHAN**

#### **Moss Landing Marine Laboratories**

Jonathan Geller is an invertebrate zoologist and molecular ecologist with research interests in molecular systematics, population genetics, and evolutionary biology especially as these relate to biological invasions specifically and biogeographic patterns of adaptation of populations and species generally. He is a native Californian, born in Los Angeles and educated in the University of California system, with a BS in Zoology at UC Davis, a MS in Ecology from UC Davis, and PhD in Zoology at UC Berkeley. His graduate research was conducted at the Bodega Marine Laboratory. He has had stints at other marine labs as Visiting Assistant Professor and Postdoctoral Research Associate at the Oregon Institute of Marine Biology, and NSF Postdoctoral Fellow in Marine Biotechnology at Hopkins Marine Station of Stanford University. He was Assistant and Associate Professor at the University of North Carolina at Wilmington from 1993-1998, then joining the faculty of Moss Landing Marine Laboratories as Associate Professor and was promoted to Full Professor in 2005. He is the 2007 800 meter champion in the M45-49 class in the Pacific Association chapter of USA Track and Field, and finished 1040th of 22,500 runners in the 2007 Boston Marathon.

### **GREGORIO, DOMINIC**

#### **State Water Resources Control Board**

Dominic Gregorio is a Senior Environmental Scientist, managing the Ocean Unit in the Division of Water Quality of the State Water Resources Control Board. The Ocean Unit is responsible for the development and updating of statewide water quality control plans, policies, and standards involving marine waters, including the California Ocean Plan, the California Thermal Plan, and the development of sediment quality objectives in bays and estuaries. Previously, Mr. Gregorio was Environmental Projects Coordinator

at the Southern California Marine Institute (SCMI). While at SCMI he was a principle investigator on harmful algal blooms and pollution research, aquaculture projects, and marine grass surveys in Los Angeles Harbor. He has been a marine biology instructor at California State University, Dominguez Hills (CSUDH), and at Cypress College in Orange County, California. At CSUDH his assignments included the teaching of distance learning classes in Marine Biology and Global Warming. From 1979 through 1987 Mr. Gregorio was an environmental coordinator for Texaco USA, West Coast Producing Division. At Texaco he managed a number of marine biological surveys and studies of offshore oil drilling projects, and was also responsible for oil spill contingency planning. Mr. Gregorio holds a M. S. Degree in Environmental Biology from California State University, Dominguez Hills.

#### **HAVEY, TIM**

##### **Tetra Tech, Inc. Lakewood, Colorado**

Tim Havey is a Senior Environmental Scientist/NPDES Compliance Specialist currently serving as a wastewater engineering consultant with the multi-national consulting services firm Tetra Tech, Inc. Mr. Havey has been involved in many aspects of the National Pollutant Discharge Elimination System (NPDES) program, including storm water and municipal and industrial discharge issues. His particular area of expertise is the analysis of technology alternatives used to reduce impingement and entrainment impacts associated with operation of cooling water systems at steam-electric power plants. In his role as lead technology analyst for Tetra Tech, he has supported US EPA in the development of the Phase I and Phase II rules implementing CWA Section 316(b) by evaluating applications of various screening, diversion and flow reduction technologies. He received his BS from Fordham University and is currently an MSE candidate at the Colorado School of Mines.

#### **LARGIER, JOHN**

##### **University of California, Davis**

John Largier is Professor of Coastal Oceanography at the University of California's Bodega Marine Laboratory. Prior to 2004, he was a research oceanographer at Scripps Institution of Oceanography. Dr Largier has also held positions at the University of Cape Town and the National Research Institute for Oceanology (CSIR) in South Africa. His research and teaching on coastal oceanography is centered on the role of transport in ocean, bay, nearshore and estuarine waters. His work has addressed issues as diverse as marine reserves, fisheries, conservation, mariculture, coastal water quality, wastewater discharge, desalination, stormwater, river plumes, coastal power plants, kelp forests, wetlands, marine mining, dredging, coastal zone management and the impacts of coastal development. Dr. Largier is a leader in developing the field of "environmental oceanography" through linking traditional oceanographic study to critical environmental issues. In 2001 he was an Aldo Leopold Leadership Fellow. He has degrees in Mathematics and Physics and a Ph.D. degree in Oceanography from the University of Cape Town (South Africa).

#### **MAULBETSCH, JOHN**

##### **Maulbetsch Consulting**

John S. Maulbetsch is currently a consultant to government and industry in the areas of energy and environment, advanced power system technologies and global sustainability. His focus in the past two years has been on water conserving alternative cooling technologies for electric power generation. From 1975 through 1998, he held a number of senior technical positions at EPRI (formerly the Electric Power Research Institute). His activities during that time included developing energy technology strategies for global sustainability, authoring "Electrification and Global Sustainability" portion of EPRI's Electricity Technology Strategy Roadmap, developing and coordinating EPRI's central exploratory effort and leading several major programs in the Environmental Control Systems area. Before joining EPRI, Dr. Maulbetsch was with Dynatech Corporation in Cambridge, Massachusetts for seven years. He was Director of the Energy Technology Center for the company. From 1965 to 1968, Dr. Maulbetsch was an Assistant Professor of Mechanical Engineering and Ford Post-Doctoral Fellow of Engineering at the Massachusetts Institute of Technology.

**MILLER, ERIC****MBC Applied Environmental Sciences**

Eric received his BA from Pitzer College in Claremont, California in 1999. He later completed his MS under Dr. Larry Allen at CSU Northridge specializing in ichthyology and marine fish ecology. His graduate research concentrated on the reproductive behavior and captive breeding of spotted sand bass (*Paralabrax maculatofasciatus*). After completing his graduate studies he joined the staff of MBC Applied Environmental Sciences in Costa Mesa, California. At MBC, Eric manages multiple large-scale environmental monitoring programs as well as original research studies. He has been actively studying the life history parameters of California's coastal marine fishes since his undergraduate studies, particularly concentrating on sciaenids and serranids. Much of his previous work has concentrated on the juvenile/adult stages, but since joining MBC his focus has shifted towards the early life stages.

**MUSSEN, TIMOTHY****University of California, Davis**

Tim is currently an Ecology graduate student at the University of California at Davis, working on a Ph.D. He received his B.S in Wildlife, Fish, and Conservation Biology from UC Davis in 2000. Tim's dissertation work focuses on applied behavioral tests of sensory perception in fish, particularly investigating potential methods of guiding fish away from water intakes.

**PONDELLA, DANIEL****Occidental College**

Daniel Pondella became the director of the Vantuna Research Group at Occidental College in 1996 and an Assistant Professor of Biology in 2005. As a Los Angeles native, he has been studying the nearshore fishes of the southern California bight since 1985. He graduated from Occidental College in 1987 and started working for the Vantuna Research Group in 1988. Since then, he completed a Masters in Biology at Occidental College and a Doctorate in Biology at UCLA.

The Vantuna Research Group focuses on monitoring nearshore fish populations concentrating on time series and large spatial scale studies. They have maintained continual monitoring programs of the fish fauna of the Palos Verdes Peninsula and King Harbor, Redondo Beach since 1974. In addition to this effort, we have been monitoring fish populations in San Diego Bay, Horseshoe Kelp, Santa Catalina Island, San Clemente Island, San Nicholas Island, Santa Cruz Island, Santa Barbara Island and the Coronados Islands.

**SAIZ, STEVE****State Water Resources Control Board**

Steve earned a Bachelor of Science degree in Wildlife and Fisheries Biology from the University of CA at Davis in 1985. He has held various biology positions including: a US Forest Service intern biologist searching for spotted owls in the Siskiyou National Forest, a UCD deer researcher mapping radio-telemetry tagged mule deer in the John Muir Wilderness, and a laboratory technician at the California Department of Fish and Game's Water Pollution Control Laboratory in Rancho Cordova. Steve was an Environmental Research Scientist for the California Department of Food and Agriculture and the California Department of Pesticide Regulation for 7½ years. While at these agencies he conducted technical studies to determine environmental hazards associated with pesticide use. As an Environmental Scientist for State Water Resources Control Board for the last 12 years, Steve has assisted in the development of water quality standards for the California Ocean Plan and derived the statistical procedures used in assessing impaired water bodies.

**STEINBECK, JOHN****Tenera Environmental**

John has an M.S. in Biological Sciences from California Polytechnic State University, San Luis Obispo. He is Vice President of Tenera Environmental and has over 30 years of experience as a professional environmental scientist. He is responsible for the management of the Tenera Environmental San Luis Obispo office and has been the Principal Investigator for marine environmental studies conducted at the

Diablo Canyon Power Plant. This program is one of the largest and most extensive environmental monitoring programs conducted in the United States. He has also worked on almost all of the environmental studies on the effects of power plant cooling water intake systems conducted in California over the last ten years. On these projects he was primarily responsible for project management, study design, and the design and analysis of the fishery based models used in the assessment of results. He has been the principal or contributing author on several papers published in scientific journals including a recent paper in *Ecological Applications* on the statistical techniques used for assessing impacts from the thermal discharge at the Diablo Canyon Power Plant. He is also the principal author on a report under review for the California Energy Commission that describes aspects of the design and modeling of environmental effects of entrainment by power plant cooling water systems.

**STRANGE, ELIZABETH M.**

**Stratus Consulting**

Elizabeth has a B.S. from San Francisco State University (1980) an M.S. from University of California, Davis (Ecology) (1989), and a Ph.D., University of California, Davis (Ecology) (1995) Elizabeth is an ecologist with Stratus Consulting Inc., a natural resource science, economics, and policy firm in Washington, DC. She works on behalf of state and federal agencies on a variety of topics related to coastal resources, including fisheries assessments, regulatory and policy analysis, salt marsh restoration, water resources, and climate change. Dr. Strange also works closely with natural resource economists to develop and implement methods for integrating environmental and economic analyses. She is a member of the Resource Policy Committee of the American Fisheries Society, focusing on climate change issues. Before joining Stratus Consulting, Dr. Strange was Staff Research Associate for the Marine Resources Program of California's Sea Grant Extension Program.

**TRASK, MATHEW**

**Consultant, Project Manager, Technical Analyst**

Mathew has more than 25 years of wide-ranging experience in the energy and environmental fields, having worked as a power plant operator, electrician, sound and vibration analysis technician, electrical engineer, and science journalist, and now as an independent consultant in the energy field. He has managed extensive, in-depth studies for public agencies and private companies related to electric power generating plants, natural gas pipeline and storage projects, electric transmission and distribution projects, and water conveyance and storage projects. He was previously under contract for 4 years to the California Energy Commission, conducting studies for the Integrated Energy Policy Report (IEPR) process, including the Aging Power Plant Study and Water-Energy Relationship Study, and managing the Commission's review of several Applications for Certification (AFCs) submitted by power plant developers seeking licenses to construct new gas-fired power plants. He is now managing an Electric Reliability Study for the State Water Resources Control Board and Ocean Protection Council related to the Board's pending decision on use of once-through cooling technology at coastal power plants.