



**PACIFIC
Estuarine Research Society**

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**PACIFIC ESTUARIES:
RECENT RESEARCH IN SCIENCE
AND MANAGEMENT**

Volume I

Proceedings

Tenth Meeting

Pacific Estuarine Research Society

December 6-7, 1982
California Academy of Sciences
San Francisco, California

-- NOTES --

1. The Pacific Estuarine Research Society gratefully acknowledges the sponsorship of the following organizations through their financial support of this meeting and in the publication of the proceedings:

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In addition, the Society greatly appreciates the support of all organizations who encourage personal membership of their staffs.

2. Names in this program followed by an asterisk (*) are non-members of the Society. Names underlined are scheduled to present the paper.
3. Abstracts are listed alphabetically by last name of primary author within each Special topic.

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**Proceedings of
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Tenth Meeting

PACIFIC ESTUARINE RESEARCH SOCIETY

The PACIFIC ESTUARINE RESEARCH SOCIETY was founded in 1978 to bring together, for educational purposes, persons interested in estuarine and coastal problems on the Pacific Coast of North America; to promote research in estuarine and coastal waters, and to promote communication among members. As an affiliate of the Estuarine Research Federation, the Society is available as a source of advice in matters concerning estuaries and the coastal zone.

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ECOLOGY OF ESTUARINE ALGAE

Convenors: Joy B. Zedler, University of San Diego
Michael Josselyn, San Francisco State University

GRACILARIA AND PACIFIC HERRING POPULATIONS IN ELKHORN SLOUGH, CA (1979-82). J. E. Hansen and R. Phillips, Marine Bioassay Laboratories, 1234 Hwy I, Watsonville, CA 95076.

Population studies of the agarophyte Gracilaria sp. and associated Pacific herring spawning activities were carried out in Elkhorn Slough, CA for three consecutive years. The red alga Gracilaria sp. and Zostera marina were the major plant substrates for herring spawn. The Elkhorn Slough Gracilaria sp. (sp. nov. Abbott & Hoyle, in press) reproduces vegetatively. Tetrasporangial and gametangial plants are rarely seen. Gracilaria standing crops varied yearly, but showed a repetitive seasonal pattern, the magnitude of which was closely associated with winter storm activity. Biomass varied from $3.2 \pm 0.3 \text{ kg fw/.5m}^2$ to $.3 \pm 0.1 \text{ kg fw/.5m}^2$ pre and post winter storms 1979-80. Subsequent regrowth and recovery of the Gracilaria populations were very slow. The herring spawning season in the slough and vicinity is from December to March. The spawns varied among years, but were always considered light by commercial standards. Biomass estimates of the spawning herring based on the season's egg deposits never exceeded 2-4 short tons/season during the 3-yr study. We thank D. Gutoff, J. Hardwick, S. Danick, J. Glasgow and many others for their dedicated help. These studies were supported by Sea Grant RF/58 (Abbott & Hansen) and the California Department of Fish & Game.

THE DISTRIBUTION AND ABUNDANCE OF MACROALGAE IN NORTHERN SAN FRANCISCO BAY. Michael Josselyn* and John West*, Tiburon Center for Environmental Studies, P.O. Box 855, Tiburon, CA 94920 and Department of Botany, University of California, Berkeley, CA 94720.

We used a permanent quadrant method to study the distribution and percent cover of seaweeds in northern San Francisco Bay. The 18-month study was conducted at four stations: Tiburon peninsula, Pt. Pinole, Carquinez Straits, and Martinez. Collections at China Camp, various rocky islands, and Angel Island provided additional distributional data. In all, 65 species were collected, the greatest diversity found at Tiburon and Angel Island during the summer months. Percent coverage was also greatest in summer months and was closely related to increasing salinities, and more frequent daytime exposure of the intertidal zone. Notable collections included four new species for the Bay: Elastichea fucicola, Centroceras clavatum, Polysiphonia denudata, and Callithamnion byssoides. The latter two, in conjunction with Ascophyllum nodosum and scorpioides, represent introductions from the Atlantic coast. Cladophora sericea, a nuisance species, may also represent an introduced variety.

SEASONAL DYNAMICS OF GREEN MACROALGAL PRODUCTIVITY IN THE COOS BAY, OREGON ESTUARY. A. Marshall Pregnall, Oregon Institute of Marine Biology, Charleston, Oregon 9/420.

Mats of the green algae Enteromorpha and Ulva dominate many tide flats in Coos Bay during summer and fall. In the laboratory these algae exhibit high photosynthetic rates if submerged or if fully hydrated when exposed; their carbon fixation declines with increased desiccation, low inorganic carbon availability, and increased self-shading. Field populations may grow with a rate of increase of 5 to 10% per day. Measurements of photosynthesis under varying conditions of light, salinity, and degree of desiccation can be extrapolated to estimate total carbon fixation by these algae. Comparisons of such growth estimates with changes in standing crop (measured at monthly intervals) yields approximate turnover rates for algal mats. By estimating how this material enters the estuarine system in various forms (e.g., dissolved organic carbon, detritus, burial and decomposition in sediments), we may infer the seasonal importance of these green algae with respect to the total estuarine productivity. This work was supported by NIH training grant 5T32 2 GM 07257 in Systems and Integrative Biology.

ESTUARINE SEDIMENT DYNAMICS

Convenor: Christopher P. Onuf, University of California, Santa Barbara

SEDIMENT DYNAMICS STUDIES ON CONTINENTAL SHELVES. David A. Cacchione* and David E. Drake*, U.S. Geological Survey, Menlo Park, CA 94025.

An instrumented tripod, GEOPROBE, has been used over the past six years to make long-term, in situ measurements of sediment dynamics parameters on Alaskan and Californian continental shelves. These measurements of near-bottom current, pressure, temperature and suspended sediment concentrations have documented significant resuspension and transport of bottom and near-bottom sediments during storms. Combined wave and quasi-steady flows, generated during infrequent storm passages, largely dominate the overall sedimentation pattern on shallow continental shelf regions. Time-averaged bottom stresses estimated from the bottom velocity profile measurements taken by the GEOPROBE strongly correlate with the suspended and bottom sediment activity, and can be used to derive local sediment flux values. These types of measurements and techniques can be applied to studies of sediment dynamics in estuaries.

CONDITIONS OF SEDIMENT DEPOSITION AND REMOVAL IN MUGU LAGOON, CALIFORNIA. C. P. Onuf, Marine Science Institute, UCSB, Santa Barbara, CA 93105.

Storms with precipitation exceeding 20 cm occurred at Mugu Lagoon in 1962, 1969, 1978 and 1980. The latter two storms deposited 13 and 6 cm of fine sediments in the eastern arm of the lagoon, respectively, while the earlier somewhat larger storms caused none, because: (1) The two storms causing sedimentation coincided with spring tides; (2) the watershed was already saturated by the fourth wettest January on record before the February 1978 storm, following three drought years; (3) the rate of agricultural development of steep slopes in the upper watershed was 8X higher after 1969 as before; (4) the central basin of the lagoon filled in completely during the 1978 storm and no longer trapped suspended particulates from floodwater before it reached the eastern arm. The earlier storms caused large mortality in organisms sensitive to low salinity, but recovery was rapid thereafter. In contrast, many effects of the later storms persist, associated with the decreased depth of the lagoon, destruction of the eelgrass beds and reduction of grain size of the bottom sediments. Tidal currents are sufficient to remobilize sediments only in the entrance channel; however, at least four processes in conjunction with the weak tidal current inside the lagoon operate to export sediments: (1) feeding and alarm movements of fish; (2) wind-generated turbulence; (3) the lifting off of algal mats with adhering sediment; (4) activities of invertebrates. Effective management of southern California's remaining wetlands must be very different, depending on the extent to which natural processes remove storm-deposited sediments.

WETLANDS AND THE ENVIRONMENTAL REGULATORY PROCESS

Convenor: Terry Huffman, Woodward-Clyde, San Francisco

POSSIBILITIES FOR HABITAT MANAGEMENT IN HILBURY SLOUGH, FRASER RIVER ESTUARY. A. H. J. Dorsey*, K. J. Hall* and D. A. Levy, Westwater Research Centre, The University of British Columbia.

Selected estuarine areas in British Columbia have been designated as conservancy areas for fish and wildlife. Because of future population growth and neighbouring urban-industrial development, long-term maintenance of desirable habitat conditions in these areas will require some form of management. Management options include protection, rehabilitation, enhancement, demonstration, and research. The Canadian federal government recently obtained legal title to Hilbury Slough, one of the few remaining semi-natural habitats in the Gravesend Reach of the Fraser Estuary. Consultations with estuarine experts in B.C. resulted in the consensus that protection of the slough from adjacent human influence including log debris, sloughing of adjacent fill, and industrial run-off was critical. Rehabilitation of flow patterns was desirable. Enhancement was not strongly recommended due to the unknown benefits to fish and waterfowl of commonly used habitat enhancement techniques. A demonstration project designed to increase public awareness of Hilbury Slough specifically, and the Fraser Estuary in general, was highly desirable. Only small-scale, site-specific ecological research programs were recommended due to the potential difficulty of extrapolating results to other downstream fish and wildlife habitats in the Fraser estuary. Implementation of these objectives will require an innovative management system that involves industrial, public and government interests.

ASPECTS OF FISH HABITAT CONSTRUCTION AT THE CAMPBELL RIVER ESTUARY, B.C. C. D. Levings, Department of Fisheries and Oceans, West Vancouver Laboratory, West Vancouver, B.C.

In January-February, 1982, five islands totalling 2.39 ha were constructed in the intertidal zone of the Campbell River estuary, B.C. Gravel from a log pond dredged into terrestrial habitat was used to build the platforms. The islands were constructed on non-vegetated gravel/cobble sites in the estuary where log storage had occurred for approximately 75 years. One of the objectives of the work was to test for fish use in relation to several factors including vegetation, food accumulation, elevation, and channel orientation. On one island tubicolous amphipods (Corophium spinicorne) and insect larvae were as abundant as at reference natural habitats after 6 months. Neomysis spp., Eogammarus confervicolus, and Lagunogammarus setosus colonized tidal channels almost immediately. The colonization of most other taxa is incomplete at the time of writing. Juvenile chum (Oncorhynchus keta) and chinook (Oncorhynchus tshawytscha) used the island habitats from March to June. There were no size differences in chums that used the islands compared to reference natural habitats. Wild chinook fry also used the new

areas in patterns similar to those shown at natural sites, but larger hatchery smolts did not. Catches of chinook and chum in upstream and downstream oriented channels on the islands were not significantly different. As the river is regulated, erosion of the islands due to freshets may be minimized. Monitoring and research of several physical and biological aspects continue. The work reported here was possible due to the support of several agencies including Fisheries and Oceans, B. C. Forest Products Ltd., and Environment Canada.

AN ASSESSMENT OF SALT MARSH RESTORATION FOR MITIGATION IN THE COASTAL ZONE. Dr. Margaret S. Race, Program in Human Biology, Stanford University, Stanford, California 94305.

Although mitigation in the form of restoration or creation of wetlands is often required as a condition of coastal development permits, questions remain about the success of previous man-made sites. A historical and field research study of west coast restoration sites indicates that there remain some significant shortcomings to this mitigation strategy. These include (1) premature declaration of success, even while sites were still under construction or development (2) variable success of different categories of restoration projects (3) lack of clear goals and requirements at the outset of projects and (4) unsuccessful application of east coast technology to west coast estuaries. Even after nearly a decade of marsh establishment technology, there are few studies comparing natural and man-made marshes in their important characteristics and none demonstrating that man-made marshes are comparable replacements for natural marshes. Marsh establishment techniques and policies are appropriate for effective coastal zone management. However, policies encouraging or allowing quid pro quo exchanges of natural marshes with man-made replacements should proceed with extreme caution. Present technology and management policies are many steps ahead of the needed supporting documentation. Previous marsh restoration and creation projects demonstrate good experimental attempts at establishing wetlands. As yet they do not provide a proven technology in large scale applications.

INTRODUCED SPECIES IN PACIFIC ESTUARIES

Convenor: Paul G. Harrison, University of British Columbia,
Vancouver

INTRODUCTION AND ESTABLISHMENT OF SPARTINA PATENS IN SIUSLAW ESTUARY, OREGON. Robert E. Frenkel and Theodore R. Boss, Department of Geography, Oregon State University, Corvallis, Oregon 97331.

Saltmeadow cordgrass (Spartina patens (Ait.) Muhl. var. patens) was introduced from the northeast Atlantic coast to Cox Island in the Siuslaw Estuary along the central Oregon coast some time prior to 1939. Analysis of a series of aerial photographs shows progressive expansion of S. patens at this only known Oregon locality. Area of establishment has expanded at a geometric rate from less than 100 m² in 1939 to more than 3,000 m² by 1981. Number of discrete circular patches of this strongly rhizomatous species has also expanded geometrically. Average patch size has increased. S. patens occupies an open, low marsh plant community (1.8-2.1 m above MLLW) typically dominated by Carex lyngbyei, Distichlis spicata, Scirpus maritimus, and Triglochin maritimum. Exhibiting highly competitive ability, S. patens has rapidly replaced local plant cover leading to single species stands. Experiments in controlling this introduction are underway. Research has been partially supported by The Nature Conservancy.

INTRODUCED AND NATIVE SPECIES OF WOOD-BORING ISOPODS (LIMNORIA) IN PACIFIC ESTUARIES. J. J. Gonor, OSU School of Oceanography and the Marine Science Center, Newport, Oregon 97365 USA.

Three of the 21 species of Limnoria have world wide distributions in marine and estuarine locations, at least in part because of introductions by man. Disjunct, reproducing populations of L. tripunctata, otherwise a warm-temperate and circumtropical species, are found in bays and estuaries in Oregon, California, Washington and British Columbia. These populations are interfertile with each other and with an Atlantic estuarine population from N. Carolina. Experiments reveal no strong differences between Los Angeles and Oregon populations in reproductive or survival adaptations to local hydrographic regimes. When compared by allozyme gel electrophoresis, L. tripunctata populations from N. Carolina, Florida, S. California and Japan are separated by smaller genetic distances than the average genetic distance between these populations and those from the Pacific Northwest. Genetic distances between Atlantic and Pacific populations of the exclusively boreal species, L. lignorum, are greater, comparable to intraspecific differences. Successful introduction of Limnoria species depends upon adult longevity, euryhalinity and eurythermality, not on most features proposed as typical of successful colonizing marine species. Work supported by the OSU Sea Grant Program and NOAA Office of Sea Grant, U.S. Department of Commerce under Grant No. NA 81AA-D-00086, Project No. R/CP-18.

ZOSTERA JAPONICA ASCHERS. & GRAEBN., A SEAGRASS RECENTLY INTRODUCED TO THE PACIFIC COAST OF NORTH AMERICA. Paul G. Harrison and Richard E. Bigley*, Dept. of Botany, University of British Columbia, Vancouver, B.C., V6T 2B1 Canada.

The seagrass Zostera japonica, recently introduced to British Columbia, Washington, and Oregon, is smaller than the native eelgrass Z. marina L.; grows best intertidally where Z. marina is rare; and is an annual, overwintering as buried seeds, or a short-lived perennial whereas Z. marina is a longer-lived perennial. Establishment of new populations of Z. japonica occurs mainly by seed germination although the chance of a seedling surviving its first summer is small. Once established, patches expand in area exponentially in spring and may help to stabilize the sediment. The fact that several areas where Z. japonica is abundant are or were sites of intensive oyster cultivation suggests that the plant was introduced as a contaminant (probably seeds) in shipments of Japanese oysters sometime in the first few decades of the 20th Century. Now common on the central coast of Washington, in northern Puget Sound, and in the southern Strait of Georgia (B.C.), Z. japonica occurs as far south as Coos Bay (Oregon) and has the potential to spread further north and south.

ROLE OF INTRODUCED SPECIES IN THE FISH ASSEMBLAGE OF A CALIFORNIA TIDAL MARSH. Peter B. Moyle and Bruce L. Herbold, Department of Wildlife and Fisheries Biology, University of California, Davis, CA 95616.

Suisun Marsh, a part of the Sacramento-San Joaquin estuary, has an assemblage of fishes consisting of 20 introduced species and 21 native species. The dominant fishes are euryhaline freshwater and marine species whose abundance both seasonally and annually is related to freshwater outflows. The exotic resident species show no consistent patterns of association while the native species tend to co-occur consistently and are ecologically segregated from each other. The introduced species show considerable dietary overlap with native species and with other introduced species. The structure of this fish assemblage is likely to change with time, although it has been fairly predictable for the past four years.

RECENT INTRODUCTION OF TWO MAINLAND CHINESE COPEPODS TO THE SACRAMENTO-SAN JOAQUIN ESTUARY. James J. Orsi, Thomas E. Bowman*, Frank D. Ferrari*, California Dept. Fish and Game, 4001 N. Wilson Way, Stockton, CA 95205 and Smithsonian Institute, Washington, D.C. 20560.

Two copepods native to Mainland China have been recently discovered in the Suisun Bay-Delta area of the Sacramento-San Joaquin Estuary. The copepods are Sinocalanus doerrii, a calanoid, first discovered by Ecological Analysts in 1978, and Limnoithona sinensis, a cyclopoid, first taken by the Dept. of Fish and Game in 1979. A third species, Oithona davisae sp. nov., found in San Francisco and San Pablo bays shows Indo-Pacific

affinities. It will have to be taken from other localities before its status can be determined. Extensive zooplankton sampling since 1971 by Fish and Game renders it unlikely that the first two copepods were introduced much earlier than their discovery dates. The assumed mode of introduction is ballast water from ocean-going ships. Exotic copepods are probably often discharged at sea ports as Carlton (1981) has shown that they can survive several months in ballast water. But their establishment is apparently uncommon as only a few cases of introductions have been documented. Since many factors militate against the establishment of exotic species, the successful introduction of two Chinese copepods in the same area at approximately the same time must be regarded as remarkable. Abundance of adults of both species now reaches several thousand per cubic meter.

CONTRIBUTED PAPERS

RESPONSE TO ULTRAVIOLET (UV-B) RADIATION BY ATTACHED ASSEMBLAGES OF ESTUARINE DIATOMS. D. L. Brooker and R. C. Worrest, Department of General Science, Oregon State University, Corvallis, Oregon 97331.

Concern over global atmospheric pollution from chlorofluorocarbons and the resulting increased levels of biologically harmful ultraviolet-B radiation (UV-B, 290-320 nm) has initiated several studies into the possible biological effects of UV-B radiation on a variety of organisms. Estuarine benthic diatoms grown on artificial substrates were exposed to UV-B and solar visible radiation in flow-through microcosms located in a greenhouse at the Oregon State University Marine Science Center in Newport, Oregon. Chlorophyll *a* concentration, biomass (ash-free dry weight), primary productivity (radiocarbon uptake) and community composition were the parameters measured at each sampling date. Results indicated an alteration of community composition following UV-B exposure. Analysis of biomass, chlorophyll *a* and radiocarbon uptake data indicated no significant depression of these parameters by UV-B radiation during each experiment. In fact, in some experiments UV-B radiation appeared to have a beneficial effect. The survival and growth of estuarine benthic diatom assemblages on epilithic substrates did not appear to be endangered under the levels of UV-B radiation used in the present study. Although the research described in this abstract has been funded in part by the U.S. Environmental Protection Agency through an Intergovernmental Personnel Act Agreement with Oregon State University, it has not been subjected to the Agency's required peer and policy review and therefore does not necessarily reflect the views of the Agency.

ADSORPTION OF WEAK ORGANIC ACIDS ON ALUMINA. C. C. Chang* and J. A. Davis*, U.S. Geological Survey, Menlo Park, California 94025.

Adsorption behavior of salicylic and phthalic acid onto alumina is characterized as a function of pH and the ratio of surface area to acid concentration. The adsorption of these organic acids is well described by a surface complexation model. Surface charge effects as a result of adsorption are discussed. Adsorption characteristics of salicylic and phthalic acids are compared to those of natural organic matter. The importance of aluminum-organic complexation in solution is also explored. The influence that organic coatings may have on metal adsorption onto particulates is considered.

ESTUARINE DEPENDENCE AND COLONIZATION. J. W. Hedgpeth, 5660 Montecito Ave., Santa Rosa, California 95404.

The validity of "estuarine dependence" is denied by some critics on the ground that estuaries are transitory in the ecological and geological sense and cannot be depended on as critical environments for the survival of marine species in coastal environments. It has even been suggested that the only

estuarine dependent species is Homo sapiens because he lives on the shores of estuaries, and exploits their resources. Many biological phenomena associated with life in estuaries deny this anthropocentric interpretation and man may live elsewhere, sive per Syrtis iter aestuosas sive ... quae loca fabulosas lambit Hydaspes, or wherever. Estuarine opportunism might be a better word for it, for most of the species that flourish in estuaries are obviously making the best of their several possible worlds. This opportunism is a dynamic ecological phenomenon, as demonstrated by larval retention and the ability to colonize remote and unsuspecting estuaries. Many of the episodes of colonization may be attributed man's inadvertent assistance by attempting to introduce species useful to him. More often than not the desirable species have been less successful than the undesirable ones. The most spectacular example of the consequences of meddling with incompletely understood ecosystems is that of the introduction of a giant oyster drill, Rapana bezoar, into the Black Sea.

A POSSIBLE CAUSE CONTRIBUTING TO THE DECLINE IN DUNGENESS CRABS IN THE SAN FRANCISCO BAY AREA: IMPAIRMENT OF FUNCTIONAL RESPONSE BY TRACE QUANTITIES OF OXIDANT RESIDUAL. A. J. Horne, M. Bennett*, R. Valentine*, R. E. Selleck*, and P. Wild*, University of California, Berkeley and California Department of Fish and Game.

Juvenile Dungeness crabs (Cancer magister) exhibit impaired functional response when exposed to very low levels of total oxidant residual. These levels are below the level of detection under field conditions but are similar to those calculated to have been present in San Francisco Bay between 1960 and 1975. Oxidant residual is a decomposition product of chlorination of waste and cooling water. Since impaired functional response can affect a crab's ability to catch prey and escape predators, this could have contributed to the population's decline in the 1960's if the population was limited by food or predation.

FLUCTUATIONS OF TRACE METALS IN METALLOTHIONEIN AND OTHER PROTEIN FRACTIONS FROM A NATURAL POPULATION OF MACOMA BALTHICA. C. E. Johansson* and S. N. Luoma*, U.S. Geological Survey, Menlo Park, California.

An eighteen month study of trace metal fluctuations in a natural population of Macoma balthica has provided information about how these organisms partition trace elements in certain protein fractions. The study site in South San Francisco Bay is an established point source of trace metal discharge. Extracts of replicate clam samples were applied to a gel filtration column and the fractions obtained were analyzed for protein and trace metal content. Extractability of trace metals from tissues was highest in the organism when total metal concentrations were highest. The high molecular weight protein fraction (that above 43,000 daltons) contained relatively constant concentrations of Cu, Ag, and Zn through time. The middle molecular weight proteins (approximately 30,000 daltons) appear to be metallothionein-like in that they

bind large quantities of Cu, Ag, and Zn; have a low absorbance at 280 nm; and are heat stable. The trace metal concentration in this fraction fluctuates greatly with total metal fluctuation in the animal.

ESTIMATION OF SALICORNIA BIOMASS USING REMOTE SENSING TECHNIQUES. Dr. Margaret Seluk Race and Virginia Rath, Human Biology Program and Department of Biological Sciences, Stanford University, Stanford, California 94305.

Remote sensing of Salicornia vegetation was undertaken in conjunction with a comparative study of man-made and natural marshes in San Francisco Bay to estimate emergent biomass during the growing season. Preliminary results suggest that variations in biomass of Salicornia spp. are correlated with changes in spectral radiance data as measured by a hand-held radiometer with filters simulating bands 4, 5, 6 and 7 of the Landsat Multi-Spectral Scanner (MSS). Future applications of this biomass estimation technique offer the advantages of time savings over the traditional harvest method and the ability to survey and monitor larger areas of marsh in a nondestructive, efficient manner.

GROWTH OF MUSSELS SUSPENDED IN THE DILUTION-FIELD OF A MUNICIPAL WASTEWATER DISCHARGE IN SAN FRANCISCO BAY. J. C. Roth, D. W. Smith, and A. J. Horne, University of California, Berkeley.

Bay mussels (Mytilus edulis) collected from the Berkeley Pier were suspended in cages at 5 sites at varying distances from a large (ca. 85 mgd) treated municipal wastewater discharge into San Francisco Bay. In a 30-day experiment, 35 mm individuals grew ca. 10% in length and ca. 30% in weight. Growth at stations near the discharge was not significantly different from that at a reference station near the donor site. The use of caged mussels appears to be an effective and economical technique to detect the toxic and/or biostimulatory effects of wastewater discharges in the estuarine environment.

SOURCES AND SEASONALITY OF ORGANIC CARBON IN ESTUARINE FOOD WEBS OF A PUGET SOUND FJORD. C. A. Simenstad and R. C. Wissmar, Fisheries Research Institute, University of Washington, Seattle, Washington 98195.

Origins and seasonality of organic carbon entering, produced and cycled within estuarine habitats and food webs in Hood Canal, Washington, were assessed using stable carbon isotopes ($\delta^{13}\text{C}$). Potential sources of autotrophic detrital carbon obtained from primary producers in terrestrial, estuarine wetland, saltmarsh, and tideflat, and littoral and neritic marine habitats illustrated relatively distinct separation (terrestrial -29.2 to -31.0‰ , wetland and saltmarsh -24.2 and -31.0‰ , neritic phytoplankton -20.2 and -25.8‰ , eelgrass and macroalgae -9.1 and -21.9‰). POC and DOC in riverine, estuarine, littoral marine, and neritic waters ranged between -20.0 and -30.0‰ , but POC was measurably more ^{13}C -depleted in estuarine than in riverine waters. Both sources and POC and DOC pools showed marked seasonal fluctuations, with ^{13}C enrichment increasing consistently between summer and winter. Estuarine accumulations of particulate detritus had

wide-ranging $\delta^{13}\text{C}$ values according to composition, but surface foam averaged -20.0‰ uniformly. Estuarine, littoral and neritic marine detritivores, consumers, and their predators were typically more ^{13}C -depleted than terrestrial, estuarine wetland and saltmarsh, and neritic sources and than POC and DOC carbon pools. Their $\delta^{13}\text{C}$ values were, however, more representative of endogenous estuarine producers, principally eelgrass, eelgrass epiphytes, and macroalgae, or of surface foam. Seasonal ^{13}C enrichment was also evident in the carbon composition of many estuarine consumers, particularly detritivores and suspension feeders, but is not pervasive. These results suggest that the principal sources of organic carbon to these estuarine food webs are essentially endogenous but are seasonally mediated by winter influxes of terrestrially-derived carbon.

NUTRIENT COMPETITION BIOASSAYS USING ULVA LACTUCA AND MICRO-ALGAL IN ANALOG TANKS. D. W. Smith and A. J. Horne, University of California, Berkeley.

The ability of Ulva lactuca to compete with micro-algae for nutrients was studied using analog tank systems. Since factors such as nutrient concentration, turbulence and species composition can be controlled and conveniently measured, varying conditions can be created and maintained simultaneously in a system of appropriately designed tanks. U. lactuca and/or secondary treated dechlorinated municipal effluent was added to continuous-flow 3000-l tanks. U. lactuca was collected by hand from floating docks, and water containing indigenous micro-algal populations of San Francisco Bay was pumped into the analog tanks for study. Competitive interactions between the micro- and macro-algae was assessed using basic growth parameters. In both effluent-augmented and non-augmented cultures, U. lactuca dramatically outcompeted micro-algae.

THE EFFECTS OF ESTUARINE LOG DEBRIS ON THE POPULATION CHARACTERISTICS OF EOGAMMARUS CONFERVICOLUS STIMPSON, 1856 (AMPHIPODA: ANISOGAMMARIDAE). Michael J. Stanhope, Department of Biological Sciences, Simon Fraser University, Burnaby, B.C., Canada V5A 1S6.

The usage of estuaries by the logging industry can lead to a variety of environmental problems. Among these is the alteration of the benthic substrate through the settling of bark fragments. The effect of this disturbance on the population characteristics of a choice B.C. salmon food organism, Eogammarus confervicolus, is being studied in the Squamish Estuary. Both log litter and natural habitats are present within the estuary so an assessment is afforded through direct comparisons. The characteristics and parameters of concern include density, size frequency, growth, production, mortality, sex ratio and fecundity.

COMPARISON OF SEDIMENTS AND ORGANISMS IN IDENTIFYING SOURCES OF BIOLOGICALLY AVAILABLE TRACE-METAL CONTAMINATION. E. A. Thomson, S. N. Luoma,* C. E. Johansson*, and D. J. Cain, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025.

Sediments and an indicator organism (*Macoma balthica*, a deposit-feeding bivalve) were used to assess the relative importance of secondary sewage, urban runoff, a landfill containing metal-enriched ash wastes, and a yacht harbor in contributing to Ag, Cu, and Zn enrichment in South San Francisco Bay. Spatial gradients in sediments and organisms showed Cu and Ag enrichment originated from sewage discharge, whereas Zn enrichment originated from both sewage and urban runoff. Elevated concentrations of Cu in the sediments of the yacht harbor resulted from a high abundance of fine particles. The biological availability of Cu, Ag and Zn to the bivalve did not coincide with metal enrichment in sediments. The availability of Cu and Ag was greatest nearest the sewage outfall and greater in winter and spring than in summer. The availability of Zn in urban runoff appeared to be lower than the availability of Zn associated with sewage.

COMPARATIVE ANALYSIS OF BENTHIC INVERTEBRATES FROM TWO SEDIMENT COMMUNITIES IN SOUTH SAN FRANCISCO BAY. Patrick S. Turney, Edward B. Lyke, and James K. Schooley, Dept. of Biol. Sci., Cal. State Univ. Hayward, Hayward, California 94542.

A comparison of arthropod and bivalve assemblages on two different intertidal substrates was done in south San Francisco Bay. The two sites were characterized by fine mud and fine mud with shell rubble, the former located at a higher elevation on the mud flat. Faunal differences between the sites were dramatic, including significant variation in species abundance, seasonal differences in occurrence of peak numbers of individuals, and differences in faunal distribution relative to the mud/water interface. Reciprocal transplant experiments were done to investigate the influence of elevation and substrate type. After initial dramatic shifts in community structure, within six months both transplants slowly drifted towards a convergence (or mixed) community structure. The possible significance of disturbance, substrate, and life histories in this convergence are discussed.

-- NOTES --

SEASONAL PATTERNS IN BENTHIC MICROALGAE BIOMASS AND SPECIES COMPOSITION IN SAN FRANCISCO BAY. Janet K. Thompson and Richard Laws*, U.S. Geological Survey, Menlo Park, California, and U. of North Carolina, Wilmington, N.C.

Seasonal patterns in benthic microalgae biomass and species composition in the shoals of San Francisco Bay are related to changes in light availability and resuspension. Benthic biomass (chlorophyll *a*) in the southern bay peaks in spring ($100 \text{ mg}\cdot\text{m}^{-2}$) when wind and tidal resuspension is low and light availability is high. The pennate diatoms (*Nitzschia accuminata* and *N. pusilla*) dominate the spring community. A lower biomass peak occurs in fall when wind and tidal velocities again decrease. Centric diatoms (*Paralia sulcata* and *Cyclotella striata*) become prevalent in summer and fall, during and after periods of increased resuspension. Benthic microalgae biomass in the northern bay is low during spring possibly due to the high freshwater inflow, but increases in fall ($100\text{-}200 \text{ mg}\cdot\text{m}^{-2}$ chlorophyll *a*) following the summer plankton bloom and subsequent decline in the plankton biomass. *Thalassiosira decipiens* is the dominant communities in the northern bay.

NATURAL INVASION AND ESTABLISHMENT OF SPARTINA FOLIOSA TRIN. ON THE SITE OF A SAN FRANCISCO BAY SALT MARSH RESTORATION AT HAYWARD, CALIFORNIA. Katherine Cuneo, ESA/Madrone 23-B Pamaron Way, Novato, California 94947.

Two and one-half years ago tidal action was restored to 200± acres of diked historic baylands for the first time in 135 years. The funding for the earthwork was provided by the California Department of Transportation (Cal-Trans) as mitigation for fill required in the construction of a new bridge in the South Bay and was undertaken by the East Bay Regional Park District (EBRPD) on land designated for restoration by the Hayward Area Shoreline Planning Agency (HASPA). In 1981 a study by California State University, Hayward and San Francisco State University revealed that five native and nine introduced species of plants had recolonized the margins of the area but that *Spartina foliosa*, California cordgrass, had not. No experimental planting of *Spartina* on the site has been reported and this author, a consultant to the Park District during the planning of the marsh, now reports that cordgrass has naturally invaded and has become established in all areas of the restoration including the salt crystallization ponds which were felt to have extremely inhospitable soil chemistry.

LINKING THE CUMULATIVE IMPACTS OF WATERSHED DEVELOPMENT TO COASTAL WETLANDS. Thomas G. Dickert, College of Environmental Design, University of California, Berkeley.

Protection of coastal resources, such as wetlands, is partially dependent on land use activities that occur within the upstream watersheds. The purpose of this research has been to investigate the aspects of urbanization and agricultural development that may affect the estuarine environment. The work has focused on the hydrologic processes and sediment movement, which are perhaps the single most significant processes linking uplands to wetlands, and are the processes that can be positively or negatively influenced by a land use planning program.

The major focus of the research has been to develop a model land use planning system to relate the type and intensity of proposed land use within an estuary watershed to the capacity of the wetland. Case study areas in California at Elkhorn Slough, Central Monterey Bay, and Jacoby Creek watershed, Humboldt Bay have been utilized in the research. The planning system consists of an erosion susceptibility map and land disturbance targets for respective subwatershed areas. If land development is allocated to subwatersheds according to the recommended target level of allowed disturbance, and is located on lands in the lower erosion susceptibility classes, then the rate of change in the wetland environment attributable to sedimentation will not accelerate beyond current rates. The planning system thus permits the local government to account for the cumulative impact of development within the entire watershed of the estuarine system. It will then be possible to review, project by project, the contribution of a single project and its cumulative effect on the entire watershed system.

BENTHIC FAUNA OF THE POLLUTED MERSEY ESTUARY OF GREAT BRITAIN.
Rash B. Ghose, Harvey and Stanley Associates, Inc., Alviso,
California 95002 U.S.A.

This study is to assess the influences of existing domestic, industrial and agricultural concerns on the distribution, life cycle and growth of the benthic fauna of the polluted Mersey Estuary.

More than 2,000 sediment/fauna samples were collected from throughout the estuary between January 1976 and September 1977. The physical and chemical factors were also sampled, measured, and analyzed, in order to supplement this investigation.

Like most other major industrial estuaries, the Mersey has been modified by man's activities. The estuary is one of the most seriously polluted in Great Britain. The dissolved oxygen concentrations are usually less than 10% of saturation and may fall to zero. These conditions commonly occur during the summer months at low water between Warrington and Hale Head.

The distribution of the taxa throughout the Estuary and the factors controlling their distribution were determined, and analysis of the fauna showed that over 135 species were present in the Mersey Estuary. The distribution of benthic fauna has been found to be extremely variable. Major changes occur with time. The initial seasonal distribution of the young intertidal macro-invertebrate population was controlled by the physical environment. Subsequent changes through the remainder of the year on these populations was due to the effects of pollution as well as predation. Each site was considered as an ecological unit. Principal component and ordination analyses were used to study the faunal data which included 25 abundant species. An initial survey of ten selected sampling sites led to six benthic invertebrate species being chosen for detailed study. The Indicator Species Index was found to be suitable for the Inner Estuary surveys. Comparative analyses of different surveys were made.

The diversity of species was greater in the Lower Estuary (110) than in the Upper Estuary (25). The result suggests that the upper reaches of the Inner Estuary were polluted and that no macrofauna can survive there except 15 Oligochaetes species which

can adapt to a high degree of pollution. Only 14 species of macro-benthos were found to be present in the middle reaches of the Inner Estuary.

The construction of harbour works, dredging, industrial discharges and effluents of the rivers draining into the estuary, have all had as much effect on the biological communities as the direct sewage pollution from outfalls. Changes in dredging practice will have a greater effect on the biological chemistry of the estuary water than sewage treatment. It is assumed that new sewage plants will reduce the organic load, so that oxygen levels will be maintained at about 10% saturation. In achieving this minimum level in the worst parts of the estuary above Hale Head and Widnes, this will bring parallel improvements in the Mersey Narrows. So, the periodically complete absence of dissolved oxygen content in summer months, in the Upper Estuary, would be eliminated. If the Upper Estuary could approach the same conditions as the adjacent Cheshire Dee estuary where species are widespread, it would represent a remarkable recovery.

DEFINING REGULATORY JURISDICTION IN WETLANDS. Robert Terry Huffman, Woodward-Clyde Consultants, Walnut Creek, California 94596.

Since passage of the Clean Water Act in 1972, significant emphasis has been placed on the need for technology which will enable regulatory personnel to precisely delineate jurisdiction boundaries between wetland and nonwetland ecosystems in the field. To date, these efforts have resulted in the development of methodologies which range from emphasizing the use of plant indicator species to an ecosystemic approach whereby wetlands soil, hydrology, and vegetation parameters are jointly assessed when making boundary determinations. By relying on the latter approach much of the difficulty in boundary determinations in transitional areas between wetlands and upland ecosystems has been substantially reduced.

STATE AND FEDERAL PROGRAMS THAT REGULATE WETLANDS. Calvin C. Long, U.S. Army Corps of Engineers, San Francisco, California.

The U.S. Army Engineer District, San Francisco is responsible for the regulation of the discharge of dredged or fill materials in all Waters of the United States found surrounding the San Francisco Bay area. The Corps regulatory program which controls the deposition of dredged or fill material operates primarily under the legislative authorizations of:

- ° Section 10 of the River and Harbor Appropriations Act of 1899 (regulates the placement of structures, the deposition of dredge and fill materials and other work in navigable waters).
- ° Section 404 of PL 92-500, the 1972 Federal Water Pollution Control Act Amendments, and as it was amended by PL 95-217, the 1977 Clean Water Act (regulates the discharge of dredged or fill material into Waters of the United States).
- ° Section 103 of the PL 92-63, the 1972 Marine Protection, Research and Sanctuaries Act* (regulates the transporta-

tion and disposal of dredged or fill material in ocean waters).

The Corps has interpreted these statutes together with those listed in Table 1 as collectively requiring a full public interest review prior to issuing or denying a permit. The review not only considers navigational concerns but such concerns as conservation, esthetics, historic preservation, fish and wildlife, water quality and economics raised by relevant federal, state, local and private interests. The discussion I will present today will elaborate on this review process and associated state and federal permit requirements.

TABLE 1
ADDITIONAL FEDERAL STATUTES RELEVANT TO THE
CORPS OF ENGINEERS REGULATORY PROGRAM

- o Section 401 of the Clean Water Act (33 USC 1341)
- o Section 307 (c) of the Coastal Zone Management Act of 1972, as amended (16 USC 1456c)
- o Section 302 of the Marine Protection, Research and Sanctuaries Act of 1972*, as amended (16 USC 1432)
- o The National Environmental Policy Act of 1969 (42 USC 4321 to 4347)
- o The Fish and Wildlife Act of 1956 (16 USC 742a, et seq.)
- o The Migratory Marine Game-Fish Act (16 USC 760c-760g)
- o The Fish and Wildlife Coordination Act (16 USC 661-666c)
- o The Federal Power Act of 1920 (16 USC 79/a, et seq.)
- o The National Historic Preservation Act of 1966 (16 USC 470)
- o The Interstate Land Sale Full Disclosure Act (15 USC 1701, et seq.)
- o The Endangered Species Act (16 USC 1531, et seq.)
- o The Deepwater Port Act of 1974 (33 USC 1501, et seq.)
- o The Marine Mammal Protection Act of 1972 (16 USC 1361, et seq.)
- o Section 7(a) of the Wild and Scenic Rivers Act (16 USC 1278, et seq.)
- o The Ocean Thermal Energy Conservation Act of 1980 (42 USC 9101, et seq.)

* Also known as the "Ocean Dumping Act"

PACIFIC ESTUARINE RESEARCH SOCIETY
CALIFORNIA ACADEMY OF SCIENCES, SAN FRANCISCO, CALIFORNIA
SCHEDULE of PAPERS

MONDAY, December 6, 1982

ECOLOGY OF ESTUARINE ALGAE

Chairpersons: Joy Zedler, Department of Biology, San Diego State University
Michael Josselyn, San Francisco State University

0830-0855: THE DISTRIBUTION AND ABUNDANCE OF MACROALGAE IN NORTHERN SAN FRANCISCO BAY by Michael Josselyn and John West, Tiburon Center for Environmental Studies, Tiburon, California and Department of Botany, University of California, Berkeley.

0855-0920: SEASONAL PATTERNS IN BENTHIC MICROALGAE BIOMASS AND SPECIES COMPOSITION IN SAN FRANCISCO BAY by Janet K. Thompson and Richard Lewis, U.S. Geological Survey, Menlo Park, California and University of North Carolina, Wilmington.

0920-0945: GRACILARIA AND PACIFIC POPULATIONS IN ELKHORN SLOUGH 1979-1982 by J. E. Hansen and R. Phillips, Marine Bioassay Labs, Watsonville, California.

0945-1010: SEASONAL DYNAMICS OF GREEN MACROALGAL PRODUCTIVITY IN THE COOS BAY, OREGON ESTUARY by A. Marshall Pregnall, Oregon Institute of Marine Biology, Charleston, Oregon.

COFFEE BREAK 1010-1030

ESTUARINE SEDIMENT DYNAMICS

Chairperson: Chris Onuf, Marine Science Institute, University of California, Santa Barbara

1030-1055: LINKING THE ACCUMULATIVE IMPACT OF WATERSHED DEVELOPMENT TO COASTAL WETLANDS by Thomas G. Dickert, College of Environmental Design, University of California, Berkeley.

1055-1120: CONDITIONS OF SEDIMENT DEPOSITION AND REMOVAL IN MUGU LAGOON, CALIFORNIA BY Chris Onuf, Marine Science Institute, University of California, Santa Barbara.

1120-1145: SEDIMENT DYNAMIC STUDIES ON CONTINENTAL SHELVES by David A. Cacchione and D. E. Drake, U.S. Geological Survey, Menlo Park, California.

LUNCH BREAK to 1315; BUSINESS MEETING

ESTUARINE POLLUTION

Chairperson: Bob Worrest, Oregon State University, Corvallis

1315-1355: NUTRIENT COMPETITION BIOASSAYS USING ULVA LACTUCA AND MICROALGAE IN ANALOG TANKS by D. W. Smith and A. J. Horne, University of California, Berkeley.

1335-1355: RESPONSE TO ULTRAVIOLET (UV-B) RADIATION BY ATTACHED ASSEMBLAGES OF ESTUARINE DIATOMS by D. L. Brooker and R. C. Worrest, Oregon State University, Corvallis.

1355-1415: A POSSIBLE CAUSE CONTRIBUTING TO THE DECLINE IN DUNGENESS CRABS IN THE SAN FRANCISCO BAY AREA: IMPAIRMENT OF FUNCTIONAL RESPONSE BY TRACE QUANTITIES OF OXIDENT RESIDUAL by A. J. Horne, M. Bennett, R. Valentine, R. E. Selleck and P. Wild, University of California, Berkeley and California Department of Fish and Game.

1415-1435: FLUCTUATIONS OF TRACE METALS IN METALLOTHIONEIN AND OTHER PROTEIN FRACTIONS FROM A NATURAL POPULATION OF MACOMA BALTHICA by C. E. Johansson and S. N. Louma, U.S. Geological Survey, Menlo Park, California.

COFFEE BREAK 1435 to 1500

1500-1520: COMPARISON OF SEDIMENTS AND ORGANISMS IN IDENTIFYING SOURCES OF BIOLOGICALLY AVAILABLE TRACE-METAL CONTAMINATION by E. A. Thomson, S. N. Louma, C. E. Johansson and D. J. Cain, U.S. Geological Survey, Menlo Park, California.

1520-1540: GROWTH OF MUSSELS SUSPENDED IN THE DILUTION FIELD OF A MUNICIPAL WASTEWATER DISCHARGE IN SAN FRANCISCO BAY by J. C. Roth, D. W. Smith and A. J. Horne, University of California, Berkeley.

1540-1600: ADSORPTION OF WEAK ORGANIC ACIDS ON ALUMINA by C. C. Chang and J. A. Davis, U.S. Geological Survey, Menlo Park, California.

1900-2200 SOCIAL, FILMS, etc.

"ESTUARY" 12 min., National Film Board of Canada Production
"AMERICA'S WETLANDS" 28 min., U.S. EPA/Dept. of Interior, FWS

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TUESDAY, December 7, 1982

WETLANDS AND THE ENVIRONMENTAL REGULATORY PROCESS

- Chairperson: Terry Huffman, Woodward-Clyde, San Francisco
- 0830-0855: DEFINING REGULATORY JURISDICTION IN WETLANDS by Terry Huffman, Woodward-Clyde, San Francisco.
- 0855-0920: STATE AND FEDERAL PROGRAMS THAT REGULATE WETLANDS by Calvin Fong, Chief, Regulatory Function Branch, U.S. Army Corp of Engineers, San Francisco District.
- 0920-0945: AN ASSESSMENT OF SALT MARSH RESTORATION FOR MITIGATION IN THE COASTAL ZONE by Margaret A. Race, Stanford University, Stanford, California.
- 0945-1000: Discussion.

COFFEE BREAK 1000-1015

INTRODUCED SPECIES IN PACIFIC ESTUARIES

- Chairperson: Paul G. Harrison, Department of Botany, University of British Columbia, Vancouver, B.C.
- 1015-1035: ESTUARINE DEPENDENCE AND COLONIZATION by J. W. Hedgpeth, 5660 Montecito Ave., San Rosa, California.
- 1035-1055: ZOSTERA JAPONICA ASCHERS. AND GRAEBN., A SEAGRASS RECENTLY INTRODUCED TO THE PACIFIC COAST OF NORTH AMERICA by Paul G. Harrison and Richard E. Bigley, Dept. of Botany, University of B.C., Vancouver, B.C.
- 1055-1115: INTRODUCTION AND ESTABLISHMENT OF SPARTINA PATENS IN SIUSLAW ESTUARY, OREGON by Robert E. Frenkel and Theodore R. Boss, Dept. of Geography, Oregon State University, Corvallis, Oregon.
- 1115-1135: RECENT INTRODUCTION OF TWO MAINLAND CHINESE COPEPODS TO THE SACRAMENTO-SAN JOAQUIN ESTUARY by James J. Orsi, Thomas E. Bowman and Frank D. Ferrari, California Dept. Fish and Game, Stockton, California and Smithsonian Institute, Washington D.C.
- 1135-1155: INTRODUCED AND NATIVE SPECIES OF WOOD-BORING ISOPODS (LIMNORIA) IN PACIFIC ESTUARIES by J. J. Gonor, Oregon State University School of Oceanography and the Marine Science Center, Newport Oregon.
- 1155-1215: ROLE OF INTRODUCED SPECIES IN THE FISH ASSEMBLAGE OF A CALIFORNIA TIDAL MARSH BY Peter B. Moyle and Bruce L. Herbold, Department of Wildlife and

Fisheries Biology, University of California, Davis,
California.

LUNCH BREAK 1215-1330

RESEARCH AND ESTUARINE MANAGEMENT

Chairperson: Colin Levings, Fisheries and Oceans, West Vancouver
Laboratory, West Vancouver, B.C.

1330-1350: SOURCES AND SEASONALITY OF ORGANIC CARBON IN
ESTUARINE FOOD WEBS OF A PUGET SOUND FJORD by C. A.
Simenstad and R. C. Wissmar, Fisheries Research
Institute, University of Washington, Seattle,
Washington.

1350-1410: NATURAL INVASION AND ESTABLISHMENT OF SPARTINA
FOLIOSA TRIN. ON THE SITE OF A SAN FRANCISCO BAY
SALT MARSH RESTORATION AT HAYWARD, CALIFORNIA, by
Katherine Cuneo, ESA/Madrone, 23-B Pamaron Way,
Novato, California.

1410-1430: POSSIBILITIES FOR HABITAT MANAGEMENT IN TILBURY
SLOUGH, FRASER RIVER ESTUARY by A. H. J. Dorsey, K.
J. Hall and D. A. Levy, Westwater Research Centre,
University of British Columbia, Vancouver, B.C.

COFFEE BREAK 1430-1450

1450-1510: ASPECTS OF FISH HABITAT CONSTRUCTION AT THE
CAMPBELL RIVER ESTUARY, B.C. by C. D. Levings,
Fisheries and Oceans, West Vancouver Laboratory,
West Vancouver, B.C.

1510-1530: THE EFFECTS OF ESTUARINE LOG DEBRIS ON THE POPULA-
TION CHARACTERISTICS OF EOGAMMARUS CONFERVICOLUS
STIMPSON, 1856 (AMPHIPODA, ANISOGAMMARIDAE) by
Michael J. Stanhope, Dept. of Biological Sciences,
Simon Fraser University, Burnaby, B.C.

1530-1550: COMPARATIVE ANALYSIS OF BENTHIC INVERTEBRATES FROM
TWO SEDIMENT COMMUNITIES IN SOUTH SAN FRANCISCO BAY
by P. S. Turney, E. B. Lyke and J. K. Schooley,
Dept. of Biol. Sci., California State University,
Hayward.

1550-1650: DISCUSSION ON ESTUARINE MANAGEMENT
Panel Leader: Erik Metz, California Coastal
Commission