Abstracts of the

IX International Conference on Salt Lake Research

September 26 – 30, 2005; Perth Australia

Hosted by

Curtin University of Technology, Bentley, Western Australia

&

The International Society for Salt Lake Research (http://www.issslr.org)

Jacob John, Conference Secretariat (j.john@curtin.edu.au)

FREEZE DESALINATION USING CLATHRATE HYDRATES

Aral H.[1], Norgate T.

[1]CSIRO Minerals, Bayview Ave., Clayton, VIC 3169, Australia

Freeze desalination is an alternative process to reverse osmosis and evaporation for desalinating water. The process is based on the fact that dissolved salts are naturally excluded during the formation of ice crystals. The non-frozen saline component is removed at the appropriate time in the freezing process, and the frozen (fresh) water is washed to remove any remaining salts adhering to the ice crystals. The ice is then melted to produce fresh water.

The desalination of seawater to date has been limited to high cost processes such as distillation and reverse osmosis (RO). Only the countries that are able to pay a high price, mainly the Middle East and tourist destination Pacific islands, have made use of these technologies to a large extent. Desalination processes using RO technology produce potable water in Southern California at (year 2000) prices ranging from US$1.06 to US$1.59 per m^3. Multiple effect distillations are more expensive than RO desalination and they require a cheap source of energy, as in Arab Peninsula countries. Furthermore, distillation-based desalination methods require large water production capacities to lower the costs. This makes it unsuitable for mineral processing plant applications and small inland town usage in Australia.

Freeze desalination inherently uses the least amount of energy. About 100 cal/g energy is needed to convert water at 20°C to ice. In conventional distillation processes the energy required to keep the water boiling is about 620 cal/g, therefore, freezing uses only 1/6 as much energy as boiling. In freeze desalination heat could be recovered to melt the ice.

There are several processes for desalinating the seawater by freezing. Some of these ideas have been investigated through various stages of development. The indirect process is the simplest, where freezing is accomplished by circulating a cold refrigerant through a heat exchanger that removes heat from the seawater through conduction. The ice is formed on the heat exchanger surface and then must be removed, washed and melted with incoming (feed) water.

There are a number of direct freezing processes where the heat from the cold seawater is removed by direct contact of the refrigerant with the seawater. Among them clathrate desalination is the most important as it has the lowest energy requirement. This was achieved by pumping the clathrate to ocean depth of 600m through a concentric-coaxial pipeline where the temperature of the water at that depth (5 to 10°C) is suitable for clathrate hydrate formation. At this depth clathrate combines with the water to form slurry of clathrate ice crystals and brine. This slurry is sucked back to the surface through the outer pipeline, filtered to obtain clathrate ice, which is then washed with small amount of fresh water and melted to obtain potable water. The clathrate molecule is regenerated for reuse. The method therefore did not require any refrigeration energy input. The cost of potable water made in this way was estimated as US$0.50 to 0.70 per kilolitre.

At CSIRO Minerals, as the first part of a preliminary evaluation of freeze desalination processes, an estimate was made of the electrical power cost for operating a typical indirect freeze desalination plant in inland Australia.

In this paper the work done in the freeze desalination area in CSIRO will be described. The importance of the clathrate hydrate type freeze desalination will be emphasized based on the literature data.

SEASONAL DYNAMICS OF ZOOPLANKTON IN A SHALLOW EUTROPHIC, MAN-MADE HYPOSALINE LAKE IN DELHI (INDIA): ROLE OF ENVIRONMENTAL FACTORS

Arora J.[1], Mehra N.K.[1]

[1]Limnology Unit, Department of Zoology, University of Delhi, Delhi 110 007, India.

Physicochemical and biological characteristics of Old Fort Lake were studied in monthly surveys during two consecutive years (January 2000 – December 2001). The principal objective was to elucidate the influence of different environmental variables on the seasonal succession of zooplankton assemblages using Canonical Correspondence Analysis (CCA).

This small (1.6 ha), shallow, eutrophic and recreational water body is located in Delhi, which lies in the subtropical semi-arid zone of northern India. Originally, it was a wide moat surrounding the Old Fort, which was constructed by the Mughal emperor Sher Shah Suri during 1538 to 1545 A.D. In ancient times, the lake was connected to river Yamuna, however, presently the lake represents a closed hydrological basin. Rainwater is the major source of water. In addition, groundwater drawn through tube wells is used for replenishing the lake regularly.

This alkaline, hyposaline (TDS: 3.0 – 10.3 gL^{-1}) and hard water lake contains very high ionic concentration, especially nitrates. Based on overall ionic composition, this lake can be categorized as chloride-sulphate alkaline earth waters with the anion sequence dominated by $SO_4^{2-} > Cl^- > HCO_3^-$, and the cations by $Mg^{++} > Ca^{++}$. The Principal Component Analysis (PCA) indicates that the annual cycle of evaporation and precipitation largely regulates the overall seasonal variability in physicochemical profile. However, the ground water largely influences its water quality.

A total of 52 species of zooplankton were recorded. The rotifers dominated the community structure both

qualitatively as well as quantitatively. The genus *Brachionus* comprised a significant component of zooplankton community with *B. plicatilis* as the most dominant species. *B. quadridentatus*, *B. angularis*, *Lecane grandis*, *L. thalera*, *L. punctata*, *Mesocyclops* sp. and *Alona rectangula* were the common taxa. The significant environmental variables selected by CCA that explain maximum variability in the zooplankton species data were NH_3-N followed by percent saturation of DO, COD, SS, BOD, NO_2-N, rainfall, silicates and PO_4-P.

AVIAN HABITAT USE IN SALINITY GRADIENT IMPOUNDMENTS

Barnum D.A.[1], Anderson T.[1]

[1]U.S. Geological Survey, La Quinta, CA USA

Avian use of salinity gradient environments such as agricultural/industrial evaporation ponds (Tanner et al. 1999), artificial salt ponds (Anderson 1970, Britton and Johnson 1987, Carmona and Danemann 1998, Masero and Perez-Hurtado 2001, Takekawa et al. 2001), natural salt flats (Velasquez and Hockey 1992, Collazo et al. 1995), and estuaries (Ysebaert et al. 2000) has been documented at numerous sites around the world. Generally, it is found that waterbird abundance is seasonally high due to use by migrating birds. During migration, birds usually require refueling stops which makes prey availability an important factor in determining their distribution, both on a landscape scale and within a particular habitat (Myers et al. 1987, Haig et al. 1998). Many studies have found salinity gradient habitats, particularly ones with hypersaline areas, provide a stable, abundant prey base that can be utilized by birds year around (Britton and Johnson 1987, Tanner et al. 1999, Masero 2003). For any particular habitat to be suitable to birds the prey must also be accessible. Different bird species have different water depths in which foraging is ideal (Burger 1984, Takekawa et al. 2001). For these reasons, an area providing many different aquatic habitats comprised of a variety of salinities and water depths has the potential to meet the needs of the greatest number and diversity of waterbirds. This concept of a mosaic of habitats has developed quite recently and there are several studies which have assisted in the evolution and understanding of this management technique. In a recent study by Takekawa et al. (2001) bird use of hypersaline salt ponds was compared to that of the other bayland wetlands. For the period from 1982-1999 the overall abundance and diversity of birds on the mosaic of bayland habitats was greater than found on the salt pond habitat, however, the density of birds on the salt ponds was greater than on the remaining baylands (Takekawa et al. 2001). The greater diversity of birds using the non salt pond wetlands is supported by the ecological theory of increased biological diversity with increased spatial/structural heterogeneity (Krebs 1991). Meanwhile, the greater density of birds found in the hypersaline salt ponds was attributed to shorebirds attracted to the combined factors of shallow water habitat (< 10 cm) in which to forage and the temporally more consistent prey availability (Takekawa et al. 2001). Studies of bird use of agricultural wastewater ponds in Central California indicated some dramatic relationships between salinity, invertebrate productivity and bird numbers (Barnum *unpubl data*). The implications of managing mosiacs of fresh and salt gradient wetlands for ecosystem restoration are explored.

SCIENCE OF THE SALTON SEA. RESTORATION OF AN IMPORTANT INLAND SALINE LAKE IN THE SOUTHWESTERN UNITED STATES.

Barnum D.A.[1], Hurlbert S.H.[2]

[1]U.S. Geological Survey, La Quinta, CA USA. [2]Department of Biology, San Diego State University, San Diego, CA USA

The Salton Sea is the latest waterbody to be formed by Colorado River floodwaters within the geographic

area known as the Salton Trough. All of the previous water bodies evaporated to dryness because of an evaporation rate of 5.6 feet per year and rainfall of less than 3 inches per year. Unlike the pervious water bodies of the same location, the Salton Sea has not evaporated to dryness because it has a permanent water source. Most of the water reaching the Salton Sea is agricultural drainwater flowing down the New, Alamo and Whitewater Rivers. Waters reaching the Salton Sea have essentially been in equilibrium with evaporation (approximately 1.34 million acre feet) for more than a decade. The result is California's largest inland water body with a length of approximately 35 miles, a maximum width of 15 miles and a maximum depth of 51 feet (average of about 30 feet). The current Salton Sea Restoration Project was initiated in January 1998 and is the first effort to have a major focus on the bird and fish life of the Salton Sea. The Salton Sea has become increasingly important as habitat for migratory birds of the Pacific Flyway and adjacent areas because of wetland and other habitat losses. California leads the nation with a loss of 91 percent of interior wetland acreage from pre-settlement until the mid-1980's. In total, approximately 95 percent of the historic interior wetland acreage has been lost or severely impacted. Less than 0.4 percent of the surface area of California is currently comprised of wetlands. Those losses and other habitat losses within the western United States and Mexico have resulted in the Salton Sea becoming an important "mitigation waterbody" for sustaining migratory birds of the Pacific Flyway and it is a critical habitat linking distant wetlands of Pacific and Central Flyways to wintering habitats in Mexico and Central and South America.

The high rate of evaporation of surface waters results in a continual increase in the salinity of the waters of the Salton Sea. The current salinity level of approximately 46 parts per thousand (ppt) is about 25 percent more saline than ocean water (35ppt). Because most of the water reaching the Salton Sea is agriculture and municipal drainwater there is a high loading of nutrients that make the lake hypereutrophic.

The current equilibrium between inflows to the Salton Sea and evaporation has resulted in a low annual rate of increases in salinity (less than 0.5 percent per year). Arresting salinity as a means for sustaining the fishery of the Salton Sea is a major focus for the Salton Sea Restoration Project. Other issues associated with the manner in which water transfers may occur including selenium, air quality issues associated with the amount of the current Salton Sea that will become dry, loss of migratory bird habitat as the lake level recedes, and loss of recreational and economic development are additional major focal points of this project. The USGS Salton Sea Science Office has initiated integrated efforts to evaluate nutrient dynamics/modeling, contaminant risk assessments for migratory birds and human health, evaluations of various restoration alternatives, avian population dynamics, contaminant burden profiles in birds and fish, air quality related studies including sediment characterization of the Salton Sea lake bed and emissions data analysis, larval fish abundance and distribution data analysis, salinity tolerance limits for fish, pileworm population abundance and distribution, and wetland habitat restoration. Results of these comprehensive studies have been published in peer-reviewed scientific journals in several dozen individual articles. Proceedings of a symposium held in 2000 were published in *Hydrobiologia*. A more recent symposium on science of the Salton Sea was held in late March 2005 and the edited proceedings will similarly be published in *Hydrobiologia*. Results from these peer-reviewed studies have been incorporated in the development of a science-based alternative for restoration of the Salton Sea. Restoration alternatives are under development by the State of California with a legislated deadline of December 2006. The Science Office remains involved in the conduct of original science and serves as the overall science program coordinator. As the program moves forward into an adaptive management phase, feedback from scientific investigations and integrated monitoring activities will interact with programmatic decisions for restoration planning.

ACID SALINE LAKES IN AUSTRALIA: CLUES TO PAST ENVIRONMENTS AND LIFE AT MERIDIANI PLANUM, MARS?

Benison K.C.[1], Bowen B.B.[1], Mormile M.R.[2], Oboh-Ikenobe F.E.[3]

[1]Department of Geology, Central Michigan University, Mt. Pleasant, Michigan, U.S.A. [2]Department of Biology, University of Missouri, Rolla, Missouri, U.S.A. [3]Department of Geological Sciences and Engineering, University of Missouri, Rolla, Missouri, U.S.A.

The many space missions dedicated to exploring Mars, including the recent Mars Exploration Rovers (MER) mission, have accumulated intriguing images of Mars' surface and chemical analyses of Mars' atmosphere, sediments, and rocks. Of particular interest are the bedded sedimentary rocks of the Burns Formation at Meridiani Planum. Compositional analyses of these Martian rocks strongly suggests that they were deposited by acid saline surface waters and ground waters (Kargel, 2004; Squyres et al., 2004a, 2004b). For example, the rocks contain jarosite, a mineral formed only by acid waters on earth, as well as hematite and sulfate minerals. This mineral suite is rare on earth, but is a criterion for the recognition of acid saline deposition in terrestrial settings (Benison and Goldstein, 2002).

Sedimentary structures seen in the MER images of the Meridiani Planum sedimentary rocks include bedding, cross-bedding, ripple marks, mudcracks, and displacive evaporite crystals. This group of features are suggestive of ephemeral shallow saline lake waters and groundwaters. These sedimentary structures are all common in terrestrial ephemeral saline lakes.

The striking similarities in composition and sedimentary structures make acid saline lakes the best terrestrial analog for the sedimentary rocks of Mars. Acid saline lakes in southern Western Australia and northwestern Victoria seem to be some of the few natural types of these unusual environments and, therefore, may be the best modern terrestrial analog for past environments on Mars.

The best way to search for signs of past life on Mars may be to first inventory, and then understand, organisms in terrestrial analog environments. Only then will planetary paleontologists know what kinds of fossils to look for in Martian rocks.

Preliminary biological investigations of the Australian acid saline settings suggest that algae and bacteria may be the dominant life forms there. These may be the closest living things to possible past life on Mars.

BROADSCALE ANALYSIS OF PLAYA FILLING IN THE YARRA YARRA DRAINAGE SYSTEM, WESTERN AUSTRALIA.

Boggs G.S.[1], Boggs D.A.[2]

[1]GIS and Remote Sensing Group. Building 18, Charles Darwin University, Casuarina, Northern Territory, Australia, 0909. [2]School of Earth and Geographical Sciences. The University of Western Australia, 35 Stirling Highway, Crawley, Western Australia, 6009.

Rainfall disparity across the Yarra Yarra catchment produces variable spatial and temporal patterns in playa filling frequency and hydroperiod. The distribution and permanence of water in the playas has numerous geomorphological, hydrochemical and ecological implications including creating variability of habitat for a range of aquatic organisms and migratory waterbirds. AVHRR satellite data from May 2002 to May 2005 were used to map broadscale events in playa filling frequency and hydroperiod. These patterns were analysed in relation to catchment and rainfall characteristics to produce a simple filling model.

THE ROLE OF ZOOPLANKTON IN THE ECOLOGICAL SUCCESSION OF PLANKTON AND BENTHIC ALGAE ACROSS A SALINITY GRADIENT IN THE SHARK BAY SOLAR SALT PONDS.

Bruce L.C.[1], Imberger J.[1]

[1]Centre for Water Research, University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009, Australia.

The relatively low biodiversity and simple hydrodynamics make solar salt ponds ideal sites for ecological studies. We have studied the ecological gradient of the primary ponds at the Shark Bay Resources solar salt ponds, Western Australia using a coupled hydrodynamic ecological numerical model, DYRESM/CAEDYM. Seven ponds representative of the primary system were simulated with salinity ranging from 45 to 155 ppt. Six species were simulated, three phytoplankton, two microbial mat plankton, and one zooplankton as well as dissolved inorganic and particulate organic nitrogen, phosphorus and carbon. By extracting the various carbon fluxes from the model we determined the role that the introduced zooplankton, *Artemia parthenogenetica* play in grazing the particulate organic carbon from the water column in the high salinity ponds. We also examined the nutrient fluxes and stoichiometric ratios of the various organic components for each pond to determine the role that *A. parthenogenetica* play in the nutrient dynamics of the salt pond system.

A COMPARISON OF THE CYST SHELL MORPHOLOGY OF TWO *PARARTEMIA* SPECIES (CRUSTACEA: ANOSTRACA) FROM WESTERN AUSTRALIA

Campagna V.S., John J.

Department of Environmental Biology, Curtin University of Technology, GPO Box U1987, Bentley, Western Australia, 6845.

To date, there is very little published material on the Australian brine shrimp*Parartemia* and their morphology. There is an urgent need for more information on this group as they are a vital component of the ecology of inland salt lakes of Western Australia. Due to the episodic and temporary nature of these waters the use of resting stages as monitoring tools has become a necessity. Morphological characteristics of cysts are proving useful in taxonomic keys, particularly when live adults cannot be collected.

The morphological features, external and internal, of the cyst shell of two *Parartemia* species were investigated and comparisons made. Cysts (encysted embryos) were collected from the surface sediment of two inland salt lakes from the Salinaland of Western Australia, Lakes Yindarlgooda and Miranda, separated by some 500 km. Using both light microscopy and SEM, distinct morphological differences were observed in the cysts of the two *Parartemia* species in particular with the cortex, an observation not previously published. The structure of the cyst shell of *Parartemia* is described in detail and compared to that of *Artemia*, highlighting their similarities, pointing to their evolutionary affinity.

APPLICATION OF BIOTECHNOLOGY FOR MONITORING HARMFUL ALGAE IN SALT LAKE AND MARINE FOOD RESOURCES IN INDIA

Chaudhari L.P.[1], Bhole A.G.[2], Yevale A.S.[1], Yavalkar S.P.[3]

[1.]Institute for sustainable development and research, Mumbai, India. [2.]Emeritus Professor, Nagpur University, India. [3]Deputy Secretary, MSBTE, Mumbai, India.

Phytoplankton blooms, micro-algal blooms, toxic algae, red tides, or harmful algae, are all terms for

naturally occurring phenomena. About 300 hundred species of micro algae are reported at times to form mass occurrence, so called blooms. Nearly one fourth of these species are know to produce toxins. Harmful algae and their toxins pose a growing global problem for human health, aquaculture, fisheries, seafood trade, tourism and recreation, and the aquatic environment at a time when human reliance on salt lake and coastal zones for food, recreation and commerce is also expanding. In developing countries, seafood often constitutes an important or even sole source of food and protein, especially in costal areas. With the increasing problems of over fishing, aquaculture may become an increasingly important alternative for the supply of seafood. However, to minimize the risk of salt lake and sea-food poisonings and the risk of major economic losses due to fish kills, it is important to establish adequate surveillance programmes and quality control of the seafood products which will often require expert assistance from countries which have longstanding experience in biotechnological applications in salt lake and marine sector.

This study focuses on development of the plan for Monitoring and management of harmful algal blooms in salt lake and coastal water for aquaculture using biotechnology from Indian experience .The study also evaluates taxonomy and biogeography of harmful algae for increasing salt water aquaculture productivity. This study signifies that the application of biotechnologies is essential for aqua food production with special focus on Eco-physiology, biochemical and pharmacological aspects of algal toxins.

BIOCHEMICAL FEATURES OF ENCYSTED EMBRYOS OF THE ANIMAL EXTREMOPHILE *ARTEMIA*, WITH COMPARISONS TO *PARARTEMIA*

Clegg J.S.[1], Campagna V.[2]

[1]Molecular and Cellular Biology, University of California, Davis, USA, [2]Department of Environmental Biology, Curtin University of Technology, Perth, Western Australia

The brine shrimp *Artemia* is an extremophile of the animal kingdom in that it survives and thrives in hypersaline environments so harsh that most animals are excluded. Its encysted gastrula embryos, or cysts, are arguably the most resistant of all animal life-history stages to a wide variety of severe stresses, and we concentrate on those here, using *A. franciscana* from San Francisco Bay, California. The exceptional stress-resistance of these cysts is based in large part on the presence of a repertoire of biochemical and biophysical adaptations that have been studied in some detail and will be summarized. For example, the cysts contain massive amounts of two stress proteins / molecular chaperones: p26 that chaperones proteins, and artemin that we believe chaperones RNA. The importance of protecting these two classes of macromolecules is obvious, and we suppose that the abundance of these chaperones reflects that critical need. In addition, trehalose, the non-reducing disaccharide of glucose that is so vital to desiccation tolerance (at which the cysts excel), is present at a whopping 10-15 % of the dry weight.

The present study was undertaken to determine if cysts of the Australian brine shrimp, *Parartemia*, have retained these adaptations over the roughly 85 million years since these genera diverged. Thus far, these two molecular chaperones have not been detected in any other anostrocan, even those considered to be closely related to *Artemia*. Cysts from two different *Parartemia* species were collected from two hypersaline locations approximately 500 km apart in Western Australia. Using antibodies against p26 and artemin we analyzed these cysts by western immunoblotting and found that both artemin and p26 were present in these cysts, butat amounts somewhat lower than in *Artemia* cysts. Although we did not measure trehalose directly because of limitations in the amount of cysts available, a reliable indirect method of analysis indicates that this sugar is present in amounts similar to those in *Artemia* cysts.

We interpret these results as further evidence for the importance of these molecules in coping with the severe stresses that cysts of both genera endure. Reasoning that unless p26, artemin and trehalose were of substantial adaptive value they would have been lost over the course of 85 million years because of the substantial cost of their synthesis.

HABITAT PREFERENCES OF *HALOSARICA FLABELLIFORMIS* (P.G. WILSON) FROM SOUTH AUSTRALIA

Coleman P.S.J.[1], Cook F.S.[2]

[1]Delta Environmental Consulting, 12 Beach Road, St Kilda South Australia 5110. [2]South East Catchment Water Management Board, c/o Corrong Council, PO Box 1021. Tintinara South Australia 5266.

Australian salt lake samphires are poorly understood, particularly the habitat requirements of Australia's only federally listed samphire, the fan samphire *Halosarcia flabelliformis* (P.G. Wilson). Fan samphires are small deciduous forbs that are generally found growing on clay pans or sabkhas directly behind coastal barrier dunes or on salt lakes further inland.

During September 2004, thirty-six soil samples were collected from within and surrounding three stands of Fan samphires near Gulf St Vincent, South Australia. Analysis of these samples showed that pH had the greatest influence on the presence of fan samphires, with field moist chlorinity also playing a role. Oven dried chlorinity was less important, with percentage moisture having no relationship to fan samphire presence.

Soil samples were also analysed for soil particle size, however no clear correlation was found. Field observations of a light-coloured subsurface hard pan under Fan samphire locations were noted.

HYDROGEOLOGY OF SALT LAKES IN WESTERN AUSTRALIA'S INTERIOR

Commander D.P., Johnson S.L.

Department of Environment, Western Australia

Western Australian salt lakes in the interior are all associated with an early Tertiary palaeodrainage system, hence they are situated in valleys. Although surface flow along the palaeodrainages is not currently occurring in most cases, they are underlain by a continuous aquifer locally known as palaeochannels, through which very slow groundwater flow takes place.

The lakes both discharge and recharge groundwater, and provide evaporative sinks by which groundwater salinity in the palaeochannel aquifer increases markedly as the groundwater passes below the lakes. Salt lakes may be discharging groundwater, especially in the upstream part, and recharging groundwater in the downstream part.

Flooded salt lakes are an important component in understanding groundwater recharge. The salt lakes are spatially offset from the palaeochannel axis with most lakes generally overlying weathered basement. The combination of depressurisation and permeability in weathered bedrock mean that significant induced recharge may leak from the flooded lakes through the weathering profile and into the sand aquifer.

Groundwater in the palaeochannels is variable ranging from fresh (about 1000 mg/L) to hypersaline reaching concentrations of up to 320 g/L. Groundwater salinity in the palaeochannels increases below the salt lakes and is progressively diluted by ingress of lower salinity groundwater from tributaries.

Salt lakes in the interior of Western Australia have some significant differences from those in other parts

of the world, largely because of their geomorphical and hydrogeological setting. These differences have only been recognised in the past twenty years, since major development of groundwater resources by the mining industry. This paper will highlight the groundwater interaction between salt lakes and the underlying palaeochannel aquifer.

FIELD STUDY OF THE INVERTEBRATE FAUNA OF WETLANDS NEAR LAKE CAREY (WESTERN AUSTRALIA)

-
Datson B.[1], Coleman M.[1], Timms B.[2]

[1]actis Environmental Services, Perth, WA, [2]University of Newcastle, Newcastle, NSW

Field studies of 16 wetland sites around and in Lake Carey, Western Australia were carried out in March and April 2004 following substantial rain (286.4mm fell in February/March 2004) and the consequent flooding of Lake Carey and surrounding wetlands. The reasons for these studies were to increase knowledge of these wetlands for future management (there are active mines in the area), to increase knowledge for a biological database, and to obtain baseline data to compare with future studies.

A comparison was made between the aquatic fauna in the main Lake and in the many different types of wetland surrounding the Lake.

CAN SECONDARY SALINE SYSTEMS BE RESTORED?

Davis J.A.[1], Chambers J.M.[1], Strehlow K.H.[1], Sim L.L.[1], O'Connor J.[1], Hartill V.[1]

[1]Aquatic Ecosystems Research, School of Environmental Science, Murdoch University, South Street, Murdoch 6150, Western Australia

Land clearing and the replacement of deep-rooted perennial plant species with shallow-rooted annual cropping species in the Wheatbelt region of Western Australia has resulted in the rise of saline watertables. As a consequence, many previously fresh aquatic systems have now become saline. Given that secondary salinisation is so widespread throughout the Wheatbelt we need to examine the prospects for restoration of at least some of these systems. Potentially saline lakes that lie within palaeochannels may undergo at least partial restoration because some flushing of salt from these systems will occur through large episodic rain events. Similarly, large rainfall events may act to dilute lakes that have become saltier during the recent drought phase when evaporative processes have dominated. However, large episodic rainfall events may also act to increase the movement of salt into lakes and rivers. In addition to understanding climatic effects the potential for restoration will be influenced by the presence of viable seed and egg banks within the sediments of these systems. Determining the presence of viable sediment seed and egg banks is suggested as the first step in assessing restoration potential.

SALINITY LEVEL FOR OCCURRENCE OF CENTROPAGID COPEPODS (CRUSTACEA, COPEPODA, CALANOIDA) IN SHALLOW PONDS IN ANDES MOUNTAINS AND PATAGONIAN PLAINS, CHILE.

1 1

De los Rios P. , Contreras P.

[1]Universidad Católica de Temuco, Facultad de Recursos Naturales, Escuela de Ciencias Biológicas y Químicas, Casilla 15-D, Temuco, Chile.

In the Andes Mountains (14 - 27°S) and Patagonian plains (45 - 53°S) in Chile, there are numerous shallow saline and sub-saline ponds. These water bodies have important temporal and spatial variation in their salinity caused by mineral composition of their watershed or exposure to arid weather. In this study we compared the salinity level and the occurrence of centropagid copepods (Crustacea, Copepoda, Calanoida) in water bodies of both regions. In the Andes Mountains the calanoids inhabit water bodies of salinity lower than 90 g/L, and the representative species was *Boeckella poopoensis* (Marsh 1906), that occurs between 5.0 to 90.0 g/L. In Patagonian plains, the copepods occur at salinity level between 0.1 to 16.0 g/L, and within this range and most frequent species are *B. popei* (Mrázek 1901) and *Parabroteas sarsi* (Mrázek 1901). Both species are able to coexist with other calanoids species such as *B. michaelseni* (Mrázek 1901) or *B. gracilipes* (Daday 1902) at low salinity.

TOLERANCE OF *ARTEMIA SINICA* (CAI 1989), NAUPLIUS TO EXPOSITION TO NATURAL ULTRAVIOLET RADIATION

De los Rios P.[1], Acevedo P.[2], Correa F.[1]

[1]Universidad Católica de Temuco, Facultad de Recursos Naturales, Escuela de Ciencias Biológicas y Químicas, Casilla 15-D, Temuco, Chile. [2]Universidad de la Frontera, Facultad de Ingeniería, Ciencias y Administración, Departamento de Ciencias Físicas, Casilla 54-D, Temuco, Chile.

Currently the increase in ultraviolet radiation penetration has become notorious, and this situation generates alterations in ecosystems. Thus, some habitats of the brine shrimp are exposed to high levels of ultraviolet radiation, such as those in tropical latitudes or mountain zones. There is no reports of survival or tolerance of *Artemia* to ultraviolet radiation, although it would be possible that the *Artemia* genus would be tolerant to exposure to ultraviolet radiation because this genus has abundant populations in saline shallow lakes. In this study, nauplii of a commercial strain of *A. sinica* were exposed to conditions of protection and exposure to natural ultraviolet radiation (outdoor) in Temuco in January 2005. The results of the experiments do not denote differences between individuals of *A. sinica* exposed and protected to natural ultraviolet radiation, in of the differences of the intensity of natural ultraviolet radiation during the experimentation period. This situation is agree with ecological evidence that reported the abundance of *Artemia* populations in tropical shallow lakes, and with molecular studies that revealed the presence of photoprotective substances. These first studies revealed that there is a lack of detailed studies of ecological effects of ultraviolet radiation in *Artemia* populations.

MATHEMATICAL MODEL OF STRATIFICATION OF SULPHUR BACTERIA AND PROCESSES IN THE ECOSYSTEM OF MEROMICTIC LAKE SHIRA, SIBERIA

Degermendzhy A.G., Prokopkin I.G., Rogozin D.Yu.

Institute of Biophysics SB RAS, Akademgorodok, Krasnoyarsk, 660036 Russia (E-mail: ibp@ibp.ru)

The data obtained in 1996–2004 on the seasonal changes in the vertical heterogeneity of the physico-chemical and biological parameters of the thermally stratified Lake Shira ecosystem (Khakasia, Siberia) have been analysed. Four groups of microorganisms involved in the sulphur cycle formation have been distinguished: sulphur, sulphur purple, sulphur green and SRB. H_2S is oxidized to sulphate (only the green sulphur bacteria oxidize it to sulphur), and sulphate is reduced to H_2S, forming neither sulphur nor its water soluble compounds. Whereas the calculated oxygen profiles are in accord with the observed ones, both the H_2S concentration and the biomass of the sulphur-cycle bacteria are somewhat overestimated. The vertical position of the H_2S zone can be regulated by varying the organic input.

Stratification of processes, in the case of calculation with a step of value Kz (up to depth 13-14 meters, value = 1, below depth 13-14 meters, value Kz = 0.01)

The theoretical curves for the stratification of chemical and biological parameters have been brought in conformity with field observations, e.g. for the different patterns of the peaks and the biomass maxima of cyanobacteria, purple and green sulphur bacteria, oxygen, and hydrogen sulphide, and for rates of processes. The calculations revealed that for an adequate assessment of the parameters for the hydrogen sulphide zone it is necessary to introduce flows of allochthonous organic matter and a stepwise depth dependence of diffusion coefficient Kz (Figure). For the first time, theoretically, based on the form of the sulphur distribution curve, the allochthonous input of organic matter has been determined. The work was supported by grants: REC-002 of the U.S. Civilian Research & Development Foundation (CRDF) and RF Ministry of Education and Science, BRHE Program; RAS Program «Origin and Evolution of Biosphere» (contract № 10002-251/П-25/155-320/200404-074).

THE VIRUSES AND MICROBES OF AUSTRALIAN SALT LAKES AND SALTERNS.

Dyall-Smith M.L, Burns D.G., Porter K., Bath C.R., Russ B.

Department of Microbiology and Immunology, University of Melbourne, Parkville 3010, Australia

The high cell density of pigmented microbes (mainly haloarchaea) imparts the typical pink-to-red colour of salt lakes (and to the salt crystals harvested from them), and it is remarkable that the nature, metabolism and diversity of these extremely halophilic prokaryotes is so poorly understood. The ability to identify bacteria based on sequencing 16S rRNA genes from DNA extracted directly from water samples has provided considerable insight into phylogenetic diversity, but few comparative studies (between geographically separate salt lakes) have been published, and the major (dominant) microbial groups were either not known or could not be grown in the laboratory. The most famous example in the latter category is ‘the square haloarchaeon of Walsby’, a geometrically elegant member of the extremely halophilic Archaea that was first reported by A. Walsby in 1980. Our cultivation of this organism and other dominant groups of haloarchaea will be described.

Salt lakes also harbour high concentrations of viruses that parasitise and kill the cellular population, and

few of these have ever been isolated or reported in the literature. Viruses play major roles in controlling host populations, driving changes in population structure, and gene transfer, and are important components of these ecosystems. In biotech applications (eg. in open salt lakes), haloviruses could potentially be useful in suppressing unfavourable microbial groups. We have isolated a number of novel and biologically interesting examples haloviruses, including those with lemon-shaped and round morphologies. Their properties, genetic diversity and interactions with host cells will be described.

TECHNICAL FEASIBILITY OF INLAND SALINE WATER AQUACULTURE IN WESTERN AUSTRALIA – AN OSMOREGULATORY APPROACH.

Fotedar R.[1], Prangnell D.[1], Tantulo U.[1]

[1]Muresk Institute, Curtin University of Technology, 1 Turner Avenue, Bentley, WA 6102 Australia, email: r.fotedar@curtin.edu.au

Australia can play a pivotal role in the global aquaculture industry by leading the research in inland saline water (ISW) aquaculture and producing a sustainable and environmentally friendly technology. Western Australia's abundant inland saline water resource can compensate for a limited availability of coastal aquaculture sites. Development of inland saline aquaculture industry is deemed to enhance economic opportunities for rural communities by diversifying their farming options. The new industry can also assist in generating employment and providing incentives to rural youth. The income generated by ISW aquaculture can be directed towards finding and implementing other solutions to reduce salinisation problem in rural areas. Before any ISW aquaculture attempts are considered, it is imperative to understand the dynamics of ionic profile and its impact on the physiology of the targeted marine species. Past research at Aquatic Sciences has demonstrated relatively low concentration of K^+ in ISW has a detrimental impact on the survival, growth and stress of cultured species. However, this impact is significantly reduced when ISW is fortified with KCl.

Future research is aimed at developing a chemical model based on the variables like, ionic profiles of ISW, water quality parameters, species' ionic regulatory mechanisms and selected physiological responses. Determining the optimum ionic requirements through the development of a chemical model will allow aquaculturists to compare different inland saline water bodies and their suitability's to culture various target species. Aquaculturists will be able to predict the productivity of their farming systems by knowing the performances of the target species beforehand. Future research will also attempt to understand the relationship between deficiency of K^+ and $Na^+/K+$ ATPase activity and hence its impact on the ionic regulation. A molecular genetics approach will assist in understanding of the molecular basis of Na^+/K^+ ATPase synthesis and its regulation.

BIOGEOGRAPHY AND DIVERSITY OF SALT-TOLERANT CHAROPHYTES (GREEN ALGAE) FROM AUSTRALIA: COMPARISON WITH THE WORLD-WIDE FLORA

García A., Chivas A.R.

School of Earth and Environmental Sciences, University of Wollongong, NSW 2522, Australia, e-mail:adriana@uow.edu.au

Charophytes (Algae, Order Charales) inhabit fresh to hypersaline non-marine environments. Modern taxa are represented by the genera *Chara, Lamprothamnium, Lychnothamnus, Nitellospsis, Nitella* and *Tolypella*, with

~ 400 species world-wide. Around 70 species live in Australia, and they are characterised by a high degree of endemism, dioecism and lack of calcification. Charophytes collected from 150 sites within different climatic areas from Australia and from salinities ranging from 0 g L^{-1} up to 60 g L^{-1} were studied, including published data in the analyses of diversity and biogeography of the salt tolerant species. The diversity of charophytes diminishes dramatically at salinities higher than 1-2 g L^{-1} with only 13 species of the forty four taxa collected tolerating salinities between 3-20 g L^{-1}. Where salinity is in the range 30 g L^{-1} to 60 g L^{-1}(the maximum salinity at which charophytes remain fertile), only species of the euryhaline charophyte genus *Lamprothamnium* are found.

The flora of charophytes world-wide is characterised by the higher diversity of *Chara* and *Nitella*, with ~130 and ~220 species respectively. Some of the species of *Chara* with cosmopolitan and sub-cosmopolitan distribution survive low hyposaline waters (e.g. *Chara contraria, C. vulgaris, C. zeylanica*), while species found at salinities in the range hyposaline to mesosaline are more restricted in their distribution (e.g. *C. canescens, C. galioides* from Eurasia; *C. halina, C. longifolia, C. hornemannii* restricted to the Americas; *C. preissii, C. leptopitys* restricted to Australia). The genus *Nitella* is a typical dweller of freshwater environments, with few species tolerating hyposaline conditions (e.g. the cosmopolitan *N. hyalina)*. The other salt-tolerant species found in Australia are endemic and dioecious (e.g. *N. verticillata, N. ungula*). The genus *Lamprothamnium* has a world-wide distribution, excepting central and north America, with eight species recognised around the world, five of them found in Australia and three of them being endemic. The genus *Tolypella*, represented by ~ 16 species world wide, has ~ 4 salt-tolerant species. It is also a typical freshwater taxon, with two species found in Australia, both with cosmopolitan distribution, but only *T. glomerata* tolerates increasing concentration of salts.

The biogeography and diversity of Australian salt tolerant charophytes are analysed and compared with the world flora, looking at endemism, dioecism, plate tectonics, and palaeogeography.

ECOLOGICAL RESPONSE TO RETURNING FLOW TO THE SOUTH LAGOON OF THE COORONG, SOUTH AUSTRALIA

Geddes M.C.[1], Grear B[2], DeJong M.[3]

[1]Environmental Biology, University of Adelaide. [2]Department of Environment and Heritage South Australia. [3]Department of Water, Land and Biodiversity South Australia

The Coorong is a long coastal lagoon system at the Mouth of the River Murray. At its northern end it receives flows that are released from the Murray Barrages and exchanges seawater through the Murray Mouth. The South Lagoon is blind-ended and receives some water exchange from the North Lagoon. Over the past decades salinities have varied from about 40 to over 120ppt. In recent years salinities have consistently been above 100ppt by the end of summer. In 2001 water became available from an agricultural and environmental drainage scheme, the Upper South east Drainage Scheme, via Salt Creek which flows into the southern end of the South Lagoon. This study considers the environmental outcomes of the 2004-05 Salt Creek outflow. About 10 to 12,000 ML flowed into the South Lagoon between October 2004 and January 2005. There was some local "freshening" of the Coorong in the vicinity of Salt Creek. Surface salinities in Salt Creek bay near the outflow were as low as 40ppt in December 2004, but salinities further offshore were over 90ppt. There was some apparent aggregation of the small-mouthed hardyhead, *Atherinosoma microstoma*, during the outflow and terns targeted the fish in the area. Comparisons with a control site 5 km away, Policemans Point, showed there was no substantial response from the halobiont macrophyte *Ruppia tuberosa* or the chironomids or microcrustaceans. The South Lagoon of the Coorong remains at an historic low in bio-diversity and productivity.

SENSITIVITY OF LAKES IN SOUTH-EASTERN AUSTRALIA TO CLIMATE AND CATCHMENT

CHANGE

Gell P.A.[1], Baldwin D.[2], Barr C.[1], Fluin J.[1], Haynes D.[1], Little F.[1], Lock S.[1], MacGregor A.[1], Tibby J.[1]

[1]Geographical and Environmental Studies, University of Adelaide, Australia. [2]Resource and Environmental Management Pty Ltd, Kent Town, SA, Australia

Diatom-based palaeolimnological approaches were used to trace salinity trends in a suite of lakes across south-eastern Australia. Late Holocene desiccation and rising salinity, widely reported from crater lakes, is also evident in coastal and floodplain systems. Post-European settlement climate change-driven increases in salinity are evident but the record in recent times is obscured by the effects of abstraction in catchments. Up to 50-fold increases in recent lake salinity are documented and implicate inter-basin transfers and irrigation-based salinisation. In contrast, some naturally saline coastal lakes have been impacted by the artificial addition of surface drainage water and have shifted to a deeper, relatively fresh state. Many of these changes occurred early in European settlement and so are beyond the experience of local landholders. Anecdotal evidence often reports on an impacted state and its value in guiding appropriate targets for rehabilitation is limited relative to sediment-based approaches.

LAKE CLIFTON: A RAMSAR WETLAND IN WESTERN AUSTRALIA – CHANGING, IRREVERSIBLY?

Goater S.E.[1], Eliot I.[1], Knott B.[2]

[1]M004 School of Earth and Geographical Sciences, The University of Western Australia, Crawley, WA 6009, Australia. [2]M092 School of Animal Biology, The University of Western Australia, Crawely, WA 6009, Australia

Lake Clifton is situated adjacent to the Indian Ocean between two major urban growth centres, Bunbury and Mandurah. The lake is part of the Yalgorup wetland system characterized by shallow, permanent interdunal lakes. Water levels reflect a balance between groundwater inputs and winter rainfall events, and loss through evaporation. In recent years, the lake has attracted attention with the extensive microbial reef being the focus of a Threatened Ecological Community initiative. Further, the Peel-Yalgorup system is listed under the Ramsar Convention as Wetlands of International Significance for providing habitats of high conservation value for migratory species of waterfowl. Claims of changes in salinity concentrations were investigated in July, 2003. Results reported here show little change prior to 1992-93 but substantial increases in salinity concentrations as great as 12.0 - 29.90 g/L since then. This change has rendered the previously unique hyposaline conditions of this lake to become hypersaline in most regions. The cause remains unknown but may be related to a change in the ground water dynamics. At the time of study, most of the 21 km long lake remained mixed with only 4 of the 36 sites sampled showing any vertical gradient to be present. Spatially, salinity concentrations increased south to north from 23.6 to 61.6 g/L. Also, a slight west to east increasing gradient was observed, reversing that from profiles previously recorded in the 1980s.

Figure 1: Time series data for: (a) annual salinity concentrations (g/L): Salinity concentrations and water level datas for 1985 to 2003 provided by the DCLM, WA. Additional records for 1984 from Knott et al. (in 2004). All values were collected in the northern end of Lake Clifton from the boardwalk.

THE INFLUENCE OF HYPERSALINE DISCHARGE WATER ON LAKE CAREY, A LARGE INLAND SALT LAKE, WESTERN AUSTRALIA.

Gregory S.J.[1], Ward M.J., [1] Campagna V.S. [12]

[1]Outback Ecology Services, Perth, Western Australia
[2]Department of Environmental Biology, Curtin University of Technology, GPO Box U1987, Perth, WA, 6845

Lake Carey is a large temporary salt lake located in the eastern goldfields of Western Australia, approximately 50km south-west of Laverton. The lake is approximately 1000 km^2, with small islands accounting for 250 km^2 of this area. Currently, the lake receives hypersaline discharge water from two mining operations, but historically there has been up to three mines discharging at any given time. Outback Ecology Services (OES) was commissioned to investigate the effects of the dewatering discharge on the Lake Carey ecosystem, by the Lake Carey Catchment Management Group (LCCMG).

Changes in the water and sediment chemistry appear to be strongly related to both seasonal variation and the hypersaline discharge water onto the lake. During the dry phase of the hydro cycle, the influence of the discharge water is more apparent than during the filling stage of the cycle. 'Recovery' of the sediment and water chemistry was initiated by the filling events from cyclonic rainfall, which ameliorate the effects of dewatering discharge in the short term.

Data collected thus far indicates variation between in the biotic assemblages of the hypersaline discharge sites and the control sites, however large rainfall events may allow for the colonisation of microalgae, cyanobacteria and invertebrate species previously not recorded at the discharge sites.

MAPPING AND MODELLING AUSTRALIAN BLACK SWAN FEEDING HABITAT FROM LAKE WOLLUMBOOLA, NSW, AUSTRALIA

Hindle M., García A., Woodroffe C., Jones B.

School of Earth and Environmental Sciences, University of Wollongong, NSW 2522, Australia

Saline coastal lakes and lagoons have high conservation value because they are breeding areas for Australian and migratory birds. These water bodies are as well subjected to increasing anthropogenic pressure, which makes management and conservation policies important issues to address. The ecology, in particular the feeding habitat, of the black swan (*Cygnus atrata*) from Lake Wollumboola, NSW is analysed, mapped and modelled, in order to understand which are the best ways to preserve the lake, and provide a rationale for its management as well as provide an example for the management of other coastal lakes.

The black swan is an endemic non-migrant species distributed across Australia, with concentrated populations in the southeast of Australia, especially Victoria and the southeast coast of NSW. Its habitat consists primarily of open water, fresh to saline, in which they can feed, roost and loaf on the surface; they have a diet of submerged aquatic algae and plants as well as terrestrial pasture and crops. The charophytes *Lamprothamnium succinctum* and *L. macropogon* within coastal and saline inland lakes, as well as the macroalgae *Cladophora, Chaetomorpha* and *Enteromorpha intestinalis*, and the angiosperm *Ruppia* spp. are the main part of their diet.

Lake Wollumboola (34° 57´ S, 150° 46´ E) was chosen because it is one of the few large, saline coastal lakes from New South Wales, still in an almost pristine condition and supporting a large stable population of black swans, with numbers exceeding 12,000 during 1998. The lake is separated from the ocean by a sandbar, the water is clear and moving, with salinities of 10-30 gL^{-1} (though it reached 70 gL^{-1} in 1991), and a sandy bottom. During bi-monthly sampling during 2004, *L. succinctum* was found in abundance between depths of 0-4 m, mixed with *Ruppia* sp., *Cladophora* sp., and *Potamogeton* sp. in areas less than 2 m depth. Samples of macrophytes and invertebrates were collected along numerous transects across the lake using GPS, to explore the aquatic plants community composition within the lake, their distribution and relationships with the counting/distribution of black swans, as well as the water level, salinity, water temperature and pH. Invertebrates were identified and species of both marine and non-marine origin distinguished.

Records of bird count and water depth collected during the last 10 years were statistically analysed and compared with the new set of data. The results indicate that there is a significant correlation between bird count and water level. Producing the model in a GIS will assist in management strategies for protecting coastal lakes along the south coast of NSW with the potential to monitor changes over spatial and temporal scales.

SALT LAKE CONSERVATION IN SOUTH AUSTRALIA – HIT OR MYTH?

Hudson P.J.

48 Thorne Crescent, Mitchell Park, Adelaide, South Australia 5043

The inclusion of large episodic salt lakes such as Lakes Eyre, Torrens and Gairdner within the South Australian Reserve Systems creates the false impression that these habitats are adequately conserved in South Australia. Only about 13% of the episodic salt lakes lie within the Reserves. They are being conserved without adequate knowledge of their fauna, without knowledge of how their fauna compares with that of other salt lakes and without plans to address these deficiencies.

There is in fact a diverse endemic fauna living on episodic lakes. Data will be presented to illustrate why this fauna should be considered when addressing the issue of salt lake conservation.

GROUNDWATER ESTUARIES OF SALT LAKES: BURIED POOLS OF ENDEMIC BIODIVERSITY ON THE WESTERN PLATEAU, AUSTRALIA

Humphreys W.F.[1], Watts C.H.S.[2], Cooper S.J.B.[2], Leijs R.[2], Bradbury J.H.[3]

[1]Western Australian Museum. [2]South Australian Museum. [3]University of Adelaide.
bill.humphreys@museum.wa.gov.au

Where groundwater abuts the ocean in porous or cavernous substrates, the intrusion of marine waters below fresher groundwater forms subterranean or groundwater estuaries. These have been most studied biologically in the context of anchialine habitats, which are near-coastal groundwaters influenced by marine tides but lacking surface marine connection. They typically exhibit marked chemoclines, associated with which are relictual obligate subterranean faunas that are locally endemic. There is increasing recognition that significant hydrogeochemical (e.g., Charette's 'Iron curtain') and biological processes (e.g., microbiologically driven N or S species cascades) may be associated with the salt front gradient in groundwater estuaries in porous aquifers generally.

Although unrecognised, groundwater estuaries also occur where groundwater flow enters lakes that are more saline. As it approaches a salt lake, groundwater assumes many of the attributes of marine estuaries. We develop the concept of groundwater estuaries associated with salt lakes and show, from studies on the ancient western plateau of Australia, that such groundwater estuaries have complex structure and display marked physico-chemical gradients along, across and through the groundwater flowpath. From first principles and the application of Ghyben-Herzberg principle, we may expect the form and dynamics of the saltwater front to mimic that of marine estuaries. However, being driven by intermittent groundwater recharge, and also lake filling, the dynamic and temporal response to changing hydrology will be heavily dampened with expected periodicity 10^{-2} to 10^{-4} that of marine estuaries.

Chains of salt lakes have formed in the palaeovalleys of the arid western plateau of Australia which represent the base level of a series of isolated groundwater flowpaths. The hydrogeochemistry of the groundwater changes along its flowpath such that as it approaches a salt lake carbonates are deposited, the accumulations of which are referred to as groundwater or phreatic calcretes. Adjacent to salt lakes the calcrete aquifers take on the attributes of groundwater estuaries. They support diverse biological communities containing macro and microinvertebrates (amphipod, isopod, copepod, ostracod and syncarid crustaceans, hydrobiid gastropods and diving beetles (Dytiscidae)) that are restricted to groundwater of a given calcrete mass, that is they are short range endemic stygobites. In some cases, the contained fauna is quite old, diving beetles for example becoming stygobiont between c. 5-8 million years ago. The persistence of these ancient stygofaunas indicates that these groundwater estuaries have been persistent *in situ* for much longer periods than typical marine estuaries, subject as they are to orogenic and geomorphological changes.

A PRACTITIONERS VIEW OF MODERN DEVELOPMENTS IN LIMNOLOGY.

Imberger J., Antenucci J., Bruce L., Dallimore C., Ducas A., Ewing T., Feaver S., Hipsey M., Imerito A., Lam C., Morillo S., Romero J., Shimizu K.

With the great advances in process understanding, sensor and instrumentation technology and modelling capability it is important to ask what if any practical benefits can the lake manager and operator look forward to. Here, we examine some of the more important problems facing operators of drinking reservoirs, hydro-lakes and lakes used predominantly for recreation and the environment. In drinking reservoirs the main problems originate from increased loadings of nutrients leading to increased biomass and biomass that may give rise to toxins, of anthropogenic chemicals such as metals and synthetic organics and of pathogens of different types. Hydro-lakes are predominantly plagued by problems arising from low oxygen levels in the hypolimnion and in recreational and environmentally sensitive lakes the biggest challenge for the operator is to maintain an existing or establish a new trophic hierarchy or protect the water body from foreign species. The control variables that are at an operator's disposal are the choice of lake water level, the modification of the water column stratification via a de-stratification system, the modification of the lake flow path with flow intervention curtains, intervention in the catchments to modify the loadings flowing into a lake, manipulation of the trophic chain with introduction of new species and chemical dosing, the latter being of marginal use in a large lake. Each of these options is cost

effective under certain circumstances. We endeavour to provide a users guide for their application and show how, especially new instrumentation and modelling methodologies may be used to achieve an effective intervention.

BRINE SHRIMP POPULATION DYNAMICS IN HYPERSALINE MONO LAKE: INTERACTIONS AMONG MIXING REGIMES, SALINITY, AND RECRUITMENT BOTTLENECKS

Jellison R.

Marine Science Institute, University of California, Santa Barbara, CA 93106-6150 USA

Long-term (1979-present) monitoring of the seasonal population dynamics of the brine shrimp, *Artemia monica*, in hypersaline (70-94 g kg^{-1}) Mono Lake has revealed trends and behaviors that would not be apparent in shorter-term studies. The past three decades included two periods of meromixis (persistent salinity stratification) (1983-1988, 1995-2003) initiated by large climatic variation coupled with water management policies. Associated changes in salinity, temperature, and phytoplankton abundance have revealed causal interactions that markedly affect the seasonal abundance of brine shrimp.

In temperate Mono Lake, over-wintering *Artemia monica* cysts hatch in early spring as water temperatures warm. Individuals of the spring generation develop through 11 larval instar stages before maturing in late May or early June. A variable fraction of 1^{st} generation individuals reproduce ovoviviparously producing a second generation which matures much more rapidly at warm summer temperatures. Ovoviviparous reproduction declines through the summer as individuals switch to oviparous (cyst) reproduction and thus abundance declines during autumn to near zero by late autumn or early winter.

The mean adult abundance of the spring (May-June), summer (July-September), and autumn (October-December) populations have varied from 3,000 to 65,000 m^{-2}, 16,000 to 62,000 m^{-2}, and 250 to 28,000 m^{-2}, respectively, during the period of study. Spring abundance is not correlated with the 3-fold variation observed in cyst production from the previous year. Rather a multiple linear regression on mean spring temperature, chlorophyll, and salinity explains 43% (adj. r^2) of the observed variation in spring adult abundance. Although adult *Artemia* may live several months, summer abundance is not correlated with spring abundance and is inversely correlated with May/June ovoviviparous reproduction. A pronounced larval bottleneck experienced by early instars at low phytoplankton concentrations (<1 µg chl *a* L^{-1}) accounts for this observation. Small changes in June phytoplankton abundance result in 4-fold changes in recruitment into the summer population. Autumn abundance is largely due to summer ovoviviparous reproduction and was significantly reduced during meromictic conditions. Variation in spring and autumn abundances affect large breeding gull colonies and migrating grebes, respectively.

SALT LAKES OF WESTERN AUSTRALIA – SALIENT FEATURES, THREATS AND CONSERVATION ISSUES.

John J., Handley M., CampagnaV., Taukulis F., Thomas E.

Dept. of Environmental Biology, Curtin University Of Technology, GPO Box U1987, Perth, WA 6845.

A panoramic view of the salt lakes – both coastal and inland predominantly from a biological perspective

is presented as a result of research projects generated by postgraduate projects, research training as well as consultancy work.

The coastal and inland salt lakes of Western Australia are among the most ecologically significant systems of this planet. The saline and hypersaline coastal lakes and marine embayments of Western Australia harbour the largest array of microbialites – stromatolites and thrombolites. The microbial communities and the water quality nurturing these unique structures have been investigated over the past 25 years. Shark Bay, salt lakes of Rottnest Island and Lake Clifton are unique saline ecosystems with vast areas of living microbialites undergoing impacts such as eutrophication, erosion, siltation and increase in salinity. The Esperance Salt Lakes, like most of the coastal salt lakes, are the legacy of sea level changes in the recent and geological past. Clearing of native trees, broad acre agriculture and encroaching urbanisation are some of the threats identified in these systems. While most of the coastal salt lakes are permanent, the inland salt lakes are temporary. They may be episodic, seasonal or intermittent.

Several inland salt lakes have been investigated over the past 20 years focusing on the limnology, biota and conservation issues. Unpredictable rainfall, prolonged dry spells and unique flora and fauna with intriguing life cycle strategies to combat these challenges, characterise the inland salt lake systems. They are mostly palaeodrainage channels associated with significant mineral resources. The mode of assessing the water quality, biodiversity and sediment characteristics of these lakes remain problematic.

The limnological changes and the triggering of life cycles of biota associated with the hydrocycle with its filling and drying periods were studied in some of the largest inland salt lakes eg. Lake Carey, Lake Lefroy and Lake Miranda. Human impacts on the ecological integrity of the lakes are discussed. Tools developed for monitoring the impacts and conservation values are suggested in this paper.

PREDICTING THE LOSS OF RIVERINE MACROINVERTEBRATE SPECIES FROM INCREASING SALINITY IN EASTERN AUSTRALIA.

Kefford B.J.[1], Dunlop J.[2], Hassel K.L.[1], Zalizniak L.[1], Prasad R.[3], Horrigan N.[2], Fields E.[1], Clay C.[1], Metzeling L.[4], Nugegoda D.[1], Choy S.[2]

[1]Biotechnology and Environmental Biology, RMIT University, PO Box 71, Bundoora, 3083, Victoria. [2]Department of Natural Resources and Environment, 120 Meiers Rd, Indooroopilly, 4068, Queensland. [3] School of Integrative Biology, University of Queensland, St Lucia, Queensland, 4072. [4]EPA, Ernest Jones Drive, Macleod, 3085, Victoria; Australia.

Due to historical land clearing salinity is increasing in many Australian freshwater bodies and there is concern for protection of freshwater biodiversity. Here we outline a study predicting the loss of macroinvertebrate species from increasing salinity. The acute lethal salinity tolerances (72-h LC_{50}) of riverine macroinvertebrates were compared from several locations across eastern Australia: the Barwon River and the southern Murray Darling Basin (MDB) in Victoria and southeast Queensland, northern MDB and tropical Australia in Queensland. Some differences in the species sensitivity distributions (SSDs) were observed between these locations although there were generally similar proportions of taxa having their LC_{50} values exceeded across the range of electrical conductivity (EC) studied and the differences between the SSDs were partly due to the richness of particular higher taxa in each location. We thus suggest that salinity tolerance data from one location may be applicable in other locations after an adjustment for the relative richness of higher taxa at a given location.

Sub-lethal and early life stage effects of salinity were studied in a sub-set of species. The eggs or hatchlings of insects and gastropods studied were more sensitive than their older life-stages while the hatchlings of the decapods studied had similar acute lethal tolerance to that of their adults. In most species there was

evidence of a stimulatory effect from salinity, where slightly elevated salinity increased growth, development and/or reproduction, followed by a maximum in these sub-lethal responses. As salinity increased further these sub-lethal responses were adversely affected. However, with sub-lethal data collected from only seven macroinvertebrates species there is no apparent pattern of responses between species.

The three most common ionic proportions in south-eastern Australia saline waters had no effect of the acute lethal salinity tolerance but these proportions affected sub-lethal tolerance. Likewise pH did not affect acute lethal salinity tolerance and high (alkaline) pHs decreased sub-lethal salinity tolerance.

Finally we compared the loss of macroinvertebrate species from salinity predicted by a SSD to the actual loss of species in Victorian rivers. The number of species per sample in Victorian rivers was invariant of salinity. However, where the number of species was determined over multiple samples, a reduction in species richness with increasing salinity was evident. This reduction matched that predicted by the SSD after the application of an exponential, or related quadratic, safety factor. Thus, it is possible to predict the loss of species in the field from laboratory salinity tolerance data, which will have many biodiversity management applications.

WATERBIRD COMMUNITY DYNAMICS IN SALINE WETLANDS OF EASTERN AUSTRALIA 1983-2004

Kingsford R.T. [1], Porter J.L. [2]

[1]School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW 2156, Australia. [2]Department of Environment & Conservation.

Australia's aridity and soils have produced tens of thousands of saline wetlands that flood episodically after intense rainfall events, becoming highly productive habitat for waterbirds. Despite this, saline wetlands in Australia are often undervalued for their importance to waterbirds and other organisms. They are poorly represented in conservation reserves compared to other wetland types. Gaps in knowledge about their conservation significance are compounded by remote locations and their ephemeral nature. Relatively little is known about how waterbird communities utilise saline lakes that are spatially and temporally variable.

This study examined waterbird community dynamics in saline wetlands using long term (1983-2004) aerial surveys of waterbirds that covered almost half the continent. Saline wetlands supported extremely large numbers of waterbirds, on average more than three times the number found on similar sized freshwater wetlands. Species diversity was also significantly higher in saline wetlands. Important nesting habitat for species such as the banded stilt, red-necked avocets, Australian pelicans and Caspian terns are provided by a few key wetlands such as Lakes Eyre, Galilee and Wyara. They functioned as a network of biodiversity hotspots, briefly pulsing on and off over decades on continental scale. This study shows how important such areas are to waterbird populations. Their spatial and temporal availability becomes crucial in identifying how often these wetlands are important and how waterbirds so quickly capitalise on them.

SPATIAL AND TEMPORAL ORGANIZATION OF THE SALT LAKES ECOSYSTEMS IN THE SOUTH OF WEST SIBERIA

-

-

Kirillov V.V.

Institute for Water and Environmental Problems of SB RAS, Russia

Many salt lakes are situated on all continents of Earth, where the geographical peculiarities favour their origin and long time existence. There are many salt lakes on the territory between the Ob and Irtysh - great Asian rivers. It is a convenient place to carry out a comparative ecological research since the lakes differ in origin, size, hydrochemistry (first of all in mineralization), composition and the level of development of living organisms. Some lakes of glacial origin stretch along the hollows of ancient outlet, the other, residual reservoirs are found in the place of pre-existing larger water bodies. Hyperhaline lakes Big Yarovoye, Kuchuk and Kulundinskoye, mesohaline Lake Chany are found on this relatively small territory. Lakes Kulundinskoye and Chany are distinguished by large water areas and are among the largest 253 world lakes (Hendendorf, 1990).

Since 1995 part of Lake Chany is a Ramsar site. Lake Kulundinskoye with its adjacent terrain is Ramsar Shadow List. Saline lake management for conservation of aquatic life and water quality should be conducted in another way as at freshwater reservoirs. Our research is aimed at the development of theoretical bases and practical recommendations for conservation and rational use of salt lakes ecosystems.

Spatial organization of lakes in this region is determined by its location at the boreal border of arid zone. Distinctions in mineralization in separate parts of Lake Chany have enabled a reliable inverse relationship between the amount of phytoplankton (chlorophyll *a* content) and mineralization in a mesohaline range from 1 up to 6 g/L to be determined (Kirillov at al, 2005). Temporal organization is determined by long-term fluctuations of moisture in semiarid zone on the whole and a catchment basin, in particular. In Lake Chany relationship between spatial and temporal organization is found. After the construction of dams (1971) that separated about 30 % of water area the rhythm of lake level fluctuation speeded up and became closer to a rhythm of moisture in catchment basin (Savkin et al, 2005).

The dried area of the separated section (Yudinsky pool) can be examined as a model of situation that occurred in the Aral Sea. During 1972-1977, Yudinsky pool lost 41% of its area and the salinity increased up to 20 g/L. In August 1991 water mineralization in the stretch increased to 34.3 g/L. The reduction has been taking place for more than 30 years, and in 2001 one could find only small seasonally changing part that constituted 5% of the previous one (Bulatov et al, 2005).

The investigation was supported by the President of the Russian Federation for supporting of leading scientific schools grant № 22.2003.5 and project SE 075 PIN-MATRA, Ministry of Agriculture, Nature and Food Quality (LNV) of the Netherlands.

ALGAE FROM THE GREAT SALT PLAINS, OK, USA: UNEXPECTED RANGE OF DIVERSITY AND HALOTOLERANCE

Kirkwood A.E.[1,3], Henley W.J.[1], Buchheim M.A.[2], Buchheim J.A.[2]

[1]Department of Botany, Oklahoma State University, USA. [2]University of Tulsa, USA. [3]Present address: University of Calgary, Canada.

The Salt Plains Microbial Observatory (SPMO) is based at the 65-km^2 salt flat that is part of the Salt Plains National Wildlife Refuge in north-central Oklahoma, USA. SPMO offers a unique opportunity to study a terrestrial, hypersaline microbial community that experiences wide-ranging environmental conditions such as rapid shifts in temperature (diel range up to 30° C) and salinity (0% to saturation). By varying media salinities (1%, 5%, 10%), we have isolated hundreds of algal strains directly from soil and brine-pool samples. Although taxonomic diversity is limited to three algal groups (Chlorophyta, Bacillariophyta and Cyanophyta), phylogenetic analyses based on partial 18S-26S and 16S rDNA sequences show comparatively higher diversity at the sub-genus level. *Dunaliella* isolates from the SPMO are closely allied with one another and form a monophyletic group with most other species of *Dunaliella*.

SPMO diatoms fall into numerous lineages spanning much of the 18S rDNA diversity among diatoms. Although phylogenetic analysis of partial 16S rDNA sequences from SPMO cyanobacterial isolates revealed broad cyanobacterial diversity, a plurality of isolates comprising several phylotypes was allied in the *Geitlerinema* lineage. All sets of phylogenetic analyses indicate that a number of SPMO isolates likely represent new species, and in some cases genera, for each algal group.

With respect to overall halotolerance among algal groups, cyanobacteria tend to prefer salinities below 10% NaCl, diatoms prefer a salinity range between 1-10% NaCl and chlorophytes (dominated by *Dunaliella*) can grow equally well at salinities above 1% NaCl. Some *Dunaliella* isolates that exhibit a colonial or palmelloid morphotype can grow in freshwater, whereas flagellate morphotypes require NaCl. Preliminary phylogenetic analyses indicate that the ability to grow equally well in freshwater and saltwater may be a recently derived trait for euryhaline *Dunaliella* isolates. In contrast, diatom phylogenies do not appear to be diagnostic of halophyly or halotolerance.

We hypothesize that the spatially and temporally hypervariable salt plains have driven adaptive radiation within a relatively few genera of halotolerant algae. Future work will utilize culture-independent analyses (e.g. clone libraries, and possibly morphospecies with diatoms) from field samples to determine spatial and short-term changes in community composition in relation to salinity.

ISOLATION AND CHARACTERIZATION OF ALKALIPHILES FROM SODA LAKES IN XILINHAOTER, INNER MONGOLIA AUTONOMOUS REGION OF CHINA

Kong F., Wei Y., Jia Q., Zheng, M., Tian X.

R&D Center of Saline Lake and Thermal Deposit, Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing, China; email:kfjbj2002@yahoo.com.cn

Chagan Naoer, Sanggendalai Naoer, Dageyin Naoer and Bayan Naoer are soda lakes with water salinity 8-18%, pH 9-10 in Hunsandake desert, located at Xilinhaoter, Inner Mongolia Autonomous Region of China. 89 strains were isolated from water and sediment samples collected from these four soda lakes. 71 strains of bacteria were cultured at pH 12, 37°C at lab. The physiological and 16S rRNA gene characterization was investigated with these strains. The bacterial strains were cultured at different salinity levels and pH. The results showed great diversity in phenotype and physiology. The shape of the bacteria were rod or coccoid. The clones of bacteria showed red, yellow and other colours with different shapes. Among these 71 strains, 40 are Gram positive. Phylogenetic analysis showed that most Gram positive strains belong to *Bacillus* and Gram negative isolations belong to Proteobacteria.

MICROBIAL DIVERSITY: METABOLIC AND MOLECULAR OF GREAT SALT LAKE, U. S. A.

Litchfield C.D.[1]., Dalmet S.[1], Sikaroodi M[1]., Gillevet P.M.[1], Baxter B.[2]

[1]Department of Environmental Science and Policy, Virginia, U.S.A. [2] Department of Biology, Utah, U.S.A.

Great Salt Lake (GSL) in Utah is the largest inland salt lake in North America. It is essentially two lakes because a railroad causeway was constructed across the lake in the 1950's. Currently, the North Arm is around 30% total salts while the South Arm is at approximately 12% overall. Flow is from the North Arm to the South Arm through several breaches made in the causeway. This paper describes studies performed at GSL over the last three years with emphasis on work performed in the North Arm.

Aseptically collected samples were plated on a modified casein/yeast/MgSO4/ sodium citrate medium and incubated at in situ temperatures. Total bacterial numbers in the North Arm averaged 1-2 x 10^6 to 10^8 colony forming units per mL.

Two to four litres of additional surface water were aseptically collected and centrifuged. The total DNA in the pellets was then extracted and was subjected to Length Heterogeneity-Polymerase Chain Reaction (LH-PCR) fingerprinting using fluorescent forward primers specific for halophilic Archaea (6-FAM-5'1H) or the universal primer for bacteria (6-FAM-5'27F) with H589R and 355R as the reverse primers, respectively. In LH-PCR the amplicons are separated on a denaturing polyacrylamide gel so the peak area in the electropherogram is proportional to the abundance of that amplicon in the community. Differences were observed in the abundance and specific LH-amplicons during June 2003, May 2004 and October 2004. Similar amplicon sizes and abundances were detected in October 2003 and June 2004. Clone libraries were prepared for each sample. The resulting sequences were analyzed using the Ribosomal Data Base Project sequences and between 12 and 20 genera were identified depending on the when the sample was taken. These differences were significant and will be described in the presentation along with the 2005 data.

The metabolic activity in a sample collected in February 2005, showed that eight substrates out of 95 possible substrates were susceptible to community utilization on the BIOLOG Phenotype Microarray PM1™ plates for carbon. These were D-galacatose, -ketoglutaric acid, propionic acid, acetoacetic acid, mucic acid, glyoxylic acid, and thymidine. Seven substrates on the PM3™ nitrogen plates were susceptible to degradation: L-glutamine, L-tyrosine, L-Histidine, L-serine, D-amino-N-valeric acid, xanthine, and guanosine. This implies a limited diversity of carbon sources for this community and may reflect the lowered productivity of the lake during the cold winter months.

THE EILAT SALTERN AND ITS MICROBIAL DIVERSITY

Litchfield C. D.[1], Oren A.[2], Irby A.[3], Sikaroodi M.[1], Gillevet P. M.[1]

[1]Department of Environmental Science and Policy, George Mason University, Virginia, USA. [2]The Institute of Life Science and Moshe Shilo Miverva Center for Marine Biogeochemistry, The Hebrew University of Jerusalem, Israel. [3]American Type Culture Collection, Virginia, USA.

Over a two and one-half year period from August 1996 to February 1998, samples were aseptically collected from the inlet and selected higher density salt pans in the saltern just east of Eilat, Israel. In an attempt to maximize the cultivable organisms, all samples were plated onto two different media and at four different salt concentrations. The plates were incubated at 30 C for up to four weeks. They were scored on the basis of pigmentation as well as colony size. The total colony-forming units ranged from nondetectable to 1 x 10^8 colony-forming units per mL depending on the medium and the season. Similar ranges were noted for DAPI counts, again depending on the season and location within the saltern.

Additionally, samples containing less than 15% salt were tested for the metabolic potential of the whole community using BIOLOG GNJ plates which were incubated for up to four weeks. A complex set of 57 substrates were used by the microbial community in the inlet sample from February 1998 while only 39 substrates were used by the community in August 1997. Thirty-two substrates overlapped between the two sample periods. In general, fewer substrates were eventually consumed by the higher salinity samples indication a decreased metabolic potential at the 10 to 15% salt concentrations.

Approximately 80 isolates from the various samples have been screened for their lipid profiles, production of extracellular enzymes, and salt/temperature responses.

To assess the whole community diversity using noncultivation techniques, cell pellets were obtained by centrifugation and extracted using the FastDNA Spin Kit® (For Soil) (Qbiogen). Again, depending on the sample location and season, up to 7 amplicons were detected. Clones have been prepared from samples from

1997 and 1998 and are being sequenced.

These data indicate that despite fairly constant environmental conditions in terms of temperature, sunlight, and rainfall, the microbial community in Eilat, Israel, is very dynamic. This variability in diversity has been observed in other salterns world-wide and suggests that more time-dependant studies are required in order to evaluate the true microbial diversity in solar salterns.

MANAGING THE RISKS OF SALINITY AND WATERLOGGING IN THE WESTERN AUSTRALIAN WHEATBELT

Mattiske E.M.[1], Bone B. [2], Durell G.[2]

[1]Mattiske Consulting Pty Ltd, Kalamunda, WA 6076. [2]Department of Conservation and Land Management, Narrogin, WA 6312

Predicting the decline in vegetation condition in a range of Wheatbelt environments in Western Australia is critical to the management of these areas in light of the impacts of salinity and waterlogging events on the flora and vegetation near lakes and drainage systems. Our recent flora and vegetation-mapping project in the Seagroatt Nature Reserve (Shire of Bruce Rock) highlighted the potential devasting impacts of both salinity, waterlogging and other related hydrological and altered biochemical processes on the extent and integrity of the vegetation on the fringes of the lakes and valley systems in the Wheatbelt of Western Australia.

During this project within the Seagroatt Nature Reserve (Mattiske Consulting Pty Ltd 2003), the research team investigated the potential implications of changing hydrological conditions and developed a tool to assist in predicting a range of scenarios if such events were to eventuate. The risk analysis provides a tool for managers to analyse the implications of increased hydrological changes such as flood events on the flora and vegetation values within ecosystems associated with a range of lakes and valley systems. The concepts behind this work have already been applied to other reserve systems near lakes and within the broad valley systems within the Western Australian Wheatbelt.

An earlier study by the Mattiske team (1995) for the Department of Conservation and Land Management in Western Australia highlighted the distinctive patterns of plant species that occur on gypsiferous dune systems on the fringes of many of the salt lakes in the Western Australian Wheatbelt. These distinctive patterns only highlighted the importance of managing the threats to these systems in a local and regional context.

Currently, there appears to be a global decline in the use of vegetation maps, condition maps and predictive tools for managing ecosystems. The mapping data has been used for a range of management purposes including an assessment of the options for either delaying the decline in biological values within the ecosystems or determining what other options exist for holding the decline at its current state. The availability of such risk analysis maps, with the underlying relationships with determining factors provides many opportunities for future research and management. The development of such risk management tools is critical to the management of a range of threatening processes that may impinge on currently listed species and communities, as well as other species that may be threatened in the future. Many of these species and communities occur on the fringes of these salt lake systems and within the broad valley floors. The potential applications are immense and the work as presented provides a critical baseline for understanding and managing the ecosystems in the Western Australian Wheatbelt.

DIVERSITY OF THE EGYPTIAN SODA LAKES OF THE WADI AN NATRUN AND ISOLATON AND CULTIVATON OF NOVEL HALOPHILIC ALKALITHERMOPHILES.

Mesbah N.M.[1], Abou-El-Ela S.H.[2], Wiegel J.[1]

[1]Departement of Microbiology, University of Georgia, Athens, Ga, USA. [2]Faculty of Pharmacy, Suez Canal

University, Ismailia, Egypt

The Wadi An Natrun is an elongated depression located in Egypt 90 km northwest of Cairo. The bottom of the valley is about 23 m below sea level and below the river Nile The Wadi An Natrun consists of six large, alkaline hypersaline lakes and a number of ephemeral pools. The pH of the lakes ranges from 9-11 and the NaCl concentration approaches saturation. Previous studies have shown the lakes to be habitat to dense communities of haloalkaliphilic microorganisms; however, there have not been any studies on the complete microbial diversity of these lakes. We have extracted whole community DNA from water and sediment samples from three of the large lakes of the Wadi An Natrun. The 16S rRNA gene was amplified with universal bacterial and archaeal primers, cloned and sequenced. Analysis of the sequence data showed that most of the 1021 bacterial clones analyzed fell into 6 major lineages of the domain *Bacteria*: Low G+C Gram-positive microorganisms (34%), and *Proteobacteria* (19, 13 and 4% respectively), *Cytophaga-Flexibacter-Bacteroides* (13%) and *Actinobacteria* (2%). The remaining 15% were assigned to the *Verrcuomicrobiales, Cyanobacteria, Spirochaetales, Chloroflexaceae* and candidate divisions. Only 20% of the cloned sequences had identities ≥ 95% with cultivated microorganisms isolate from other alkaline, hypersaline environments such as *Rhodobaca bogoriensis, Thiorhodovibrio sibirica, Tindallia magadii* and *Spirochaeta africana.* Comparisons of all the obtained clone libraries (each with 300 clones) show that the bacterial communities are significantly different, despite the fact that they are all fed from water originating from the river Nile.

The halophilic alkalithermophiles (haloalkalithermophiles) are a special physiological group only recently recognized, and are expected to possess unique adaptive mechanisms, such as novel transport mechanisms, osmoregulatory compounds or enzymes. They are adapted to grow at three extreme environmental conditions, high temperature, pH and salt concentration, representing an ecological as well as an evolutionarily interesting combination. Thus far, only two haloalkalithermophiles have been isolated (‘*Bacillus thermoalcalophilus’* and *Halonatronum saccharophilum*), indicating either a lack of exploration of the group or inappropriate selection of media and isolation conditions.

We have succeeded in isolation of three novel halophilic alkalithermophilic microorganisms from the Wadi An Natrun and from salt flats located in the Buffalo Springs area, Nevada. The isolates are in the Low G + C Gram positive group (*Bacillus/Clostridium*). All isolates have a large NaCl range (1-3M, 0-3M and 1-2.5M respectively) and tolerate higher NaCl concentrations than their closest relatives. They are all obligate thermophiles, not growing at temperatures below 42^{o}C (Temp$_{opt}$ 68, 64 and 60 ^{o}C respectively) and alkaliphilic (pH$_{opt}$ 9.4, 9.2 and 9.0 measured at 60 ^{o}C). Substrate utilization spectra are extreme narrow in comparison to the ones of their closest relatives.

PHYTOPLANKTON OF LAKE CHANY AND ITS YUDUNSKY POOL AS THE MOST SALINE PART OF THE LAKE SYSTEM

Mitrofanova E.Yu.

The Institute for Water and Environmental Problems of SB RAS, Russia

Area of Chany water includes several pools and it is the largest lake by its surface area in West-Siberian Lowland. There are as parts with fresh (Lake Malye Chany and mouths ofChulym and Kargat rivers) as brackish (Yudinsky Pool) water. The diversity and abundance of algae in plankton in different lake parts are determined by water salinity. Before 1971 total mineralization during the vegetation period in this lake system was 0.50-4.91 g/L. After cutting off Yudinsky Pool with the dam the lake area reduced by 700 km^2 and mineralization increased up to 20 g/L. Thus, this part of the lake is the most saline one now. In 1975-1983 131 species of algae with leading role of green algae (mainly Protococcales) were found in phytoplankton. The blue-green and diatoms were the second and third ones. The diversity of Yudinsky Pool phytoplankton was rather poor – 16 species only, mostly blue-green (40.0%) and diatom (33.3) algae, and green (20.0), Euglenophytes (6.7%) ones (Safonova, Ermolaev, 1983; Ermolaev, Vizer, 2001).

In 2001 hydrobiological investigations along the whole lake were done (Kipriyanova et al., 2002; Mitrofanova, 2002). There were 181 species of algae in phytoplankton with the richest diversity of green (47.0%), blue-green (15.5) and diatom (13.2%) algae. The most of green algae were from Protococcales again. As to compared with the previous investigations, the dominant role of Euglenophytes was observed probably due to shallow sites increase in the lake. Number and biomass of phytoplankton varied greatly: 0.2-21.1 ml.cells/L and 0.1–129.5 g/m^3 (ultraoligotrophic-hypereutrophic level of abundance correspondingly). The least number of phytoplankton was found in the most saline sites of the lake as it was early (in 1975-1983), the largest one on the contrary – in the less saline sites. The phytoplankton of Yudinsky Pool in 2001 was characterized by low diversity too – 12 species of algae with the leading role of blue-green (58.%) and green (25.0%) algae as well. *Lyngbya contorta* Lemm., *L. lutea* (Ag.) Gom., *Phormidium tenue* (Menegh.) Gom. dominated by number, *L. contorta*, *Scenedesmus quadricauda* (Turp.) Breb. and *Euglena polymorpha* Dang – by biomass.

The comparison with the obtained data with the ones of previous investigations of the lake phytoplankton revealed that blue-green algae were and are the most important group among the algae due to the whole water salinity increase here and its ability to exist in the worst environmental conditions.

The investigation was executed under support of the President of the Russian Federation for supporting of leading scientific schools № 22.2003.5 grant and project SE 075 PIN-MATRA, Ministry of Agriculture, Nature and Food Quality (LNV) of the Netherlands.

MINE WATER DISCHARGE ONTO LAKE HOPE NORTH

Moodie, S.

LionOre Australia Lake Johnston Operations, LionOre Australia Level 3, 88 Colin Street West Perth Western Australia 6005

LionOre Australia (Nickel) Limited Lake Johnston Operations (LJO) is located 540 km east of Perth, Western Australia. LJO commenced operations with the development of the Emily Ann underground nickel sulphide deposit in 2001.

Saline water management is the primary environmental issue facing the mine. Excess saline water from mine dewatering not used in the processing operation is discharged, under Department of Environment Licence, onto Lake Hope North (LHN), affecting 1 - 2 km^2 of the 150 km^2 salt lake within the 400 km^2 Lake Johnston-Lake Hope Palaeodrainage system. Water quality and invertebrate monitoring studies have been undertaken since 1998.

To gain a better understanding the effect that LionOre's activities may be having on LHN, in 2003 the monitoring programme was expanded to include metals uptake in vegetation and *Parartemia* (brine shrimp), and the chemistry of sediment deposited from the discharge. In 2004, the study was further expanded to include regional baseline data on water quality in isolated salt lake systems, and the health and metals uptake of *Parartemia* found within any of these habitats. Investigations aimed at determining the speciation and fate of metals (especially nickel) within the deposited and underlying natural sediments are currently being undertaken.

Potential impact on the lake environment was reviewed with the following objectives:

- Compare regional salt lake water quality data to the quality of mine discharge waters within LHN;
- Quantify the portioning of metals between water and sediment;
- Quantify uptake of metals into biota within the discharge affected area and in regional waters and;
- Review potential contaminant pathways for release of metals and metalloids into the environment (dust, permanent ponding, and effect to the underlying palaeodrainage water).

With the information available to date, there is no discernable negative effect on the lake environment from the discharge area in its current, permanently-saturated state. The study will continue to review biota and to acquire baseline and dynamic data to assess the potential for impacts on LHN, especially following cessation of discharge water where the sediment will be subjected to seasonal desiccation and inundation.

WETLANDS TURNING SALINE: ECOLOGICAL PREDICTIONS FROM STUDIES OF EMERGENCE FROM NSW WETLAND SEDIMENTS

Nielsen D.L[1,2], Brock, M.A.[2,3], Vogel, M.[1,2], Petrie, R.[1,2]

[1]Murray-Darling Freshwater Research Centre, P.O Box 991, Wodonga, Victoria, 3689, Australia. [2]Co-operative Research Centre for Freshwater Ecology, P.O Box 991, Wodonga, Victoria, 3689, Australia. [3]Department of Infrastructure, Planning and Natural Resources, PO Box U245, Armidale, NSW 2351, Australia.

In general, freshwater biota do not extend into saline or even slightly saline waters and salt tolerant species found in saline lakes are unlikely to thrive in freshwaters. As many of Australia's inland freshwater wetlands are becoming increasingly saline the question of what biotic communities will exist in newly saline wetlands becomes pertinent for management. To examine this we have used the emergence of aquatic plants and zooplankton from the seed and egg banks in freshwater wetland sediments as indicators of what communities may persist in the future as salinity increases.

In previous experiments we have found that constant salinity levels above 1000 mg L^{-1} reduce the richness of communities. Between 1000 and 5000 mg L^{-1} some species can survive to dominate the communities and at salinities of 5000 mg L^{-1} most freshwater zooplankton and aquatic species do not survive. Once salinities reach 15000 mg L^{-1} no freshwater species are present. For plant communities, these effects are more obvious for those communities that grow in the damp edges of a wetland than for the submerged communities developing in deeper areas.

Our most recent studies examined how gradients of salinity, similar to those that occur as a wetland becomes increasing saline over time, compare with constant levels of salinity. In an experimental mesocosm study examining the impacts of salinity on emergence from the seed and egg banks, wetland sediment was exposed to four constant salt treatments (<300, 1000, 5000 & 15000 mg L^{-1}) and two salinity gradients treatments (<300 to 1000 mg L^{-1} and <300 to 5000 mg L^{-1}). Results for both plants and zooplankton indicate that:

1. Communities that developed under either a constant salinity or along a gradient of salinity of 1000 mg L^{-1} were not as diverse as those that developed in salinities of <300 mg L^{-1}.
2. Communities that developed under constant salinities of 5000 or 15000 mg L^{-1} were not as diverse as those that developed in salinities of <300 mg L^{-1}.
3. Communities that developed along a gradient to 5000 mg L^{-1} were similar to that of the 1000 mg L^{-1} constant salinity until salinities reach 3000 mg L^{-1}. At this point diversity began to decrease.

Our results suggest that as freshwater wetlands become increasing impacted by salinity substantial modifications to aquatic communities will occur before salinities reach 3000 mg L^{-1}. We predict that few freshwater species will survive to dominate wetlands with salinities above 5000 mg L^{-1}.

ARE PRIMARY AND SECONDARY SALINISED LAKES SIMILAR?

O'Connor J.T.[1], Davis J.A.[1], Chambers J.M.[1]

[1]School of Environmental Science, Murdoch University, Australia

Many wetlands in the agricultural zone of southwestern Western Australia are undergoing secondary salinisation. This phenomenon has affected both fresh and primary saline systems. However, many primary saline systems remain in coastal areas and the uncleared, semi-arid regions of the state. There is increasing pressure to use both primary and secondary saline wetlands for the disposal of saline drainage water from agricultural land.

The possible ecological effects of altered hydrological regimes and increases in salinity on these systems are not clear. To address this, a research programme is now underway to compare water quality and ecological process in primary and secondary saline systems along a 500 km transect from the coast to the interior, over a complete wetting and drying cycle. Our research results should assist with the management, conservation and restoration of these systems.

GYPSOPHILY IN ARID AND SEMI-ARID SOUTH-EAST AUSTRALIA

O'Keefe M., Westbrooke M., Florentine S.

Centre for Environmental Management, School of Science and Engineering, University of Ballarat, Australia

Deposits of gypsum associated with playas are generally regarded as floristically poor but data on gypsophilous plants are fragmentary and often contradictory. Gypsophiles are plants that can tolerate gypsum in their lifecycle, but the role that gypsum plays in their ecology is uncertain. Research is being undertaken in south-east Australia (SA, VIC and NSW) to determine whether a suite of species is regularly associated with gypsum and how they are adapted to cope with gypsophilous soils. Sixty sites in SA, NSW and Victoria have been investigated (Fig 1). These sites include undisturbed gypsum deposits in SA and associated with the Scotia Discharge Complex in western NSW, and gypsum mine sites at Ivanhoe, western NSW and the Raak Plain of northwestern Victoria. Eighty plant species, from 28 families, have been recorded with highest representation from the Chenopodiacae and Asteraceae with 21 and 14 species respectively. Only seven species were common to both undisturbed and disturbed (mine) sites: *Kippistia suaedifolia*, *Atriplex vesicaria, Maireana pyramidata, Salsola kali, Sclerolaena muricata S. patenticuspis* and *Zygophyllum aurantiacum.* Of these, only *K. suaedifolia* appears to be confined to gypseous soils. *K. suaedifolia* is of particular significance since, although listed as endangered in NSW and vulnerable in Victoria, it thrives on three of the abandoned gypsum mine sites. Research is continuing into the adaptations that enable gypsophiles to grow on such a hostile substrate, using *K. suaedifolia* as a key indicator species.

Fig. 1: Broad study regions in NSW, VIC and SA

GEOLOGICAL INFLUENCES ON WETLAND SALINITY IN THE HOLOCENE WETLAND ROEBUCK PLAINS, NORTH WESTERN AUSTRAIA

Oldmeadow E.

Parsons Brinckerhoff, 1 Alvin St, PO BOX 1232, Subiaco WA 6008 Australia; eoldmeadow@pb.com.au

Roebuck Plains (750 km^2) lies directly east of the Ramsar wetland Roebuck Bay and the tourist locality of Broome, both situated on the Indian Ocean at the base of the Dampier Penninsula, Western Australia. The wetland lies in the drowned Eocene Crab River valley, and gained its current sedimentological configuration during the Holocene regression (circa 7.5 kY to present). Marine sediment deposited during this time had a high biogenic load, which accounts for the carbonate mineral dominated assemblage of Roebuck Plains. The wetland which is over 40 km long spans across two distinct geomorphic terrains including the Modern supratidal zone and the mid to Early Holocene deposited carbonate hinterland. Lateral vegetation profiles differ across the wetland, as do surface and groundwater hydrodynamic regimes. These changes affect the geological stability of carbonate minerals (especially aragonite) which exhibit roughly east – west temporally constrained stability trends.

Ground and surface water across Roebuck Plains exhibits broad salinity ranges. Fresh water at the edges of the wetland exhibit total dissolved solids (TDS) concentrations around 100 mg/L, whilst in the supratidal zone hypersaline water with TDS concentrations in excess of 100,000 mg/L is recorded. The vast lateral halocline affects the stability of the near surface carbonate minerals, and thus the diagenetic evolution of the Modern and Holocene carbonate terrains. These geological constraints affect the lakes, and the migratory birds that inhabit the lakes which occur in the Roebuck Plains area. Ultimately, the carbonate dominated wetland provides earth scientists insight into the interaction of highly saline aqueous systems with active geological and biological terrains.

LONG-TERM FIELD SIMULATION OF ALGAL AND ARCHAEAL BLOOMS IN THE DEAD SEA.

Oren A.[1], Gavrieli I.[2], Gavrieli J.[3], Kohen M.[4], Lati J.[4], Aharoni M.[4]

[1]The Institute of Life Sciences, and the Moshe Shilo Minerva Center for Marine Biogeochemistry, The Hebrew University of Jerusalem, Jerusalem, Israel, [2]Geological Survey of Israel, 30 Malkhei Yisrael St., Jerusalem, Israel, [3]IMI (TAMI) Institute for Research and Development, P.O. Box 10140, Haifa Bay, Israel, [4]Dead Sea Works Ltd., P.O.B. 75, Beer-Sheva, Israel

Currently a proposal is being investigated for the construction of a water carrier, the "Peace Conduit," to connect the Dead Sea with the Gulf of Aqaba (Red Sea). This planned water carrier is intended to mitigate damaging processes that currently occur in the Dead Sea and its surrounding area. It will counteract the drop in Dead Sea water level of about 1 m per year during the last decade, caused by anthropogenic intervention in the water balance of the lake. The difference in elevation between the Red Sea and the Dead Sea (current surface level: -418 m) can then be exploited for seawater desalination.

Monitoring of the biological properties of the Dead Sea from 1980 onwards has shown that dilution of the upper water layers by fresh water following unusually rainy winters triggers the development of massive development of unicellular algae (*Dunaliella*) and red halophilic Archaea of the family *Halobacteriaceae*. Such blooms have been observed twice in the past 25 years: in 1980 and in 1992. These two blooms differed in the dynamics of their appearance and decay, and finally disappeared as a result of overturn events when meromictic episodes ended, restoring the holomictic regime.

To simulate the conditions leading to microbial blooms in the Dead Sea and to study the parameters that may govern the extent and dynamics of such blooms when the salinity of Dead Sea water will be reduced by addition of Red Sea water, we have been performing field simulation experiments since 2002 in 0.9 m^3 experimental ponds on the grounds of the Dead Sea Works Ltd. at Sedom. Dilution of Dead Sea water with at least 10-15% Red Sea water triggered development of *Dunaliella* and red Archaea, similar to the natural blooms observed in the Dead Sea. However, when the salinity was reduced to below 60% Dead Sea water, mass development of unicellular cyanobacteria (*Halothece*-type) was observed as well. The extent of the simulated *Dunaliella* and Archaea blooms depended on the availability of phosphate. After an initial burst of *Dunaliella* growth the algal populations declined, but new blooms could be triggered by adding additional phosphate, suggesting that the phosphorus becomes fixed in the biomass. The community sizes of red halophilic Archaea that had developed at the expense of organic carbon fixed by the algae remained high, and sustained blooms of Archaea have now been kept in the simulation ponds for nearly three years.

MICROBIAL COMMUNITIES AND PROCESSES WITHIN A HYPERSALINE GYPSUM CRUST IN A SALTERN EVAPORATION POND (EILAT, ISRAEL).

Oren A.[1], Sørensen K.B.[2], Canfield D.E.[3], Teske A.P.[4], Ionescu D.[1], Lipski A.[5], Altendorf K.[5]

[1]Institute of Life Sciences, The Hebrew University of Jerusalem, Israel, [2]Department of Geology and Geophysics, University of Hawaii, Honolulu, HI, [3]Danish Center for Earth System Science, Institute of Biology, University of Odense, Denmark, [4]Marine Sciences Department, University of North Carolina, Chapel Hill, NC, [5]Fachbereich Biologie/Chemie, Abteilung Mikrobiologie, Universität Osnabrück, Osnabrück, Germany

Gypsum crusts containing multicolored stratified microbial communities grow in the evaporation ponds of a commercial saltern in Eilat, Israel at salt concentrations between 190 and 240‰. The upper 0.5-2 cm of the crust is densely populated by orange-brown unicellular *Halothece*-type cyanobacteria. Below, a layer of green-colored *Phormidium*-type filamentous cyanobacteria is found. Underneath a bright purple layer of anoxygenic phototrophs is present, below which a black layer is found in which sulfate reduction occurs. We have investigated the biological properties of this crust using a polyphasic approach. Phylogenetic analysis based on

16S rDNA clone libraries showed dominance of bacterial phylotypes affiliated with the *Bacteroidetes* phylum, and both photo- and chemotrophic groups of a-proteobacteria. Also detected were non-phototrophic g-, and d-proteobacteria, Planctomycetes, the TM6-group, Firmicutes, and Spirochetes. Archaeal groups detected included organisms affiliated with the *Methanosarcinales*, the *Halobacteriales*, and uncultured types of Euryarchaeota. Characteristic fatty acid patterns in each layer could be correlated to the microscopic and functional analysis of the biota present. Microelectrode studies showed that the cyanobacteria in the green layer are exposed to sulfide most of the time. Adaptation of this layer to anaerobic conditions is shown by the lack of polyunsaturated fatty acids, the apparent use of an oxygen-independent pathway of monounsaturated fatty acids biosynthesis, as well as by the ability of the cyanobacteria of anoxygenic CO_2 photoassimilation. Kinetic measurements of oxygen and sulfide formation within the crust using microelectrodes as well as radioactive and stable isotope-based measurements showed that most of the oxygen produced during the day is internally recycled, mainly in O_2 respiration. Unicellular and filamentous cyanobacteria metabolized at near-optimum rates at the in situ salinity, whereas the optimum salinity for anoxygenic phototrophs was between 100 and 120‰. The optimum salinity for the sulfate reduction rate in sediment slurries was between 100 and 120‰, and sulfate reduction was strongly inhibited at an in situ salinity of 215‰. Methanogens contributed little to the anaerobic mineralization in the crust.

AQUATIC COMMUNITIES OF SALT LAKES IN THE WESTERN AUSTRALIAN WHEATBELT

Pinder A.M., Halse S.A., Lyons, M.L., McRae, J.M.

Science Division, Department of Conservation and Land Management, P.O. Box 51 Wanneroo, Western Australia 6946, Australia

Drainage systems of inland parts of south-western Western Australia consist of ancient river valleys that have filled in since the mid-Tertiary, resulting in broad palaeodrainage flats. These flats rarely contribute surface flow to the active rivers of the higher rainfall western parts of the region but contain mosaics of salt lakes and channels. The salt lakes vary greatly in size, hydrology, salinity, acidity and vegetation. The natural hydrological patterns of many of the lakes have been altered or are threatened through the effects of land clearing on groundwater tables and schemes to drain saline groundwater from agricultural land. A biodiversity survey, undertaken between 1997 and 2001 to describe biogeographic patterning in the region for conservation planning, sampled 230 wetlands (including 63 naturally saline) for aquatic invertebrates, plants, waterbirds and water chemistry. This paper describes the physico-chemical nature and aquatic communities of the naturally saline lakes and makes some comparisons with secondarily saline wetlands.

All naturally saline lakes were seasonally or episodically filled, with highest water levels in late winter and most drying between spring and autumn. Instantaneous salinities ranged from 6.3 to 328 g L^{-1}, with Na^+ and Cl^- consistently dominating ionic composition. Aquatic vascular plant communities were dominated by amphibious species (those that tolerated both flooding and drying), with *Halosarcia* and *Sarcocornia* particularly common. Few wetlands contained submergent vascular plants and then only one or two species were present, usually *Ruppia* and *Lepilaena* spp. *Characeae* were very common. Richness of aquatic plant communities was not correlated with lake salinity. Salt lake invertebrate communities included both salt tolerant freshwater species and halophilic species, although there was considerable heterogeneity between sites. Lake salinity was a strong determinant of community composition but other variables, such as acidity and level of disturbance were also important. Halophiles constituted a larger proportion of the invertebrate fauna as salinity increased. Numerous halophilic species, especially *Parartemia* brine shrimp and some copepods and cypridid ostracods, were absent from disturbed wetlands and wetlands that were secondarily saline. These species were generally rare and many appear to be restricted to inland south-west Western Australia. Their ecological requirements are poorly understood but their persistence may be threatened by hydrological disturbance and its consequences.

MACROPHYTE BIOMASS IN SALINE WETLANDS IN NORTH WESTERN NEW SOUTH WALES, AUSTRALIA – "BOOM AND BUST" OR SEASONAL PATTERNS ?

Porter J.L.[1,2], Brock M.A.[1,3], Kingsford R.T.[4]

[1]University of New England. [2]Department of Environment & Conservation. [3]Department of Infrastructure, Planning & Natural Resources. [4]School of Biological, Earth and Environmental Sciences, University of New South Wales.

Australia's arid zone contains a diverse array of wetlands with extensive rivers, floodplains and terminal lakes that vary greatly in salinity and permanency. Erratic rainfall and river flows combined with low topographic relief produce extremely variable flooding patterns. These unpredictable flood pulses drive a spectacular "boom and bust" ecology for fauna, particularly waterbirds, fish and invertebrates.

However, despite evidence of high productivity the response of aquatic plants to flooding in arid wetlands is not well understood, particularly in saline wetlands. We compared changes in the biomass of aquatic plant communities during flood pulses and among seasons in saline wetlands from 1997-2002. Biomass was sampled in two temporary salt lakes (Clifton Downs, Salt Lake) during brief flood pulses (<12 months) and over longer periods (>36 months) in two permanent salt lakes (Altibouka and Wyara). Clifton Downs and Salt Lake are shallow (<2 m), rarely filled wetlands in the Bulloo River basin of north western NSW that filled in January 2000 and dried within 12 months. Lakes Altibouka and Wyara are deeper (<4 m), rarely dry wetlands that held water continuously throughout the study.

Macrophyte biomass in Salt Lake and Clifton Downs increased rapidly after flooding reaching maximum densities just before drying. Species diversity in both wetlands was low, with two species *Ruppia tuberosa* and *Lepilaena preissii* making up more than 95% of the biomass. In saline permanent wetlands biomass varied significantly among seasons. Lake Wyara biomass increased through winter before peaking in spring and summer and then dying back in autumn. More than 90% of the biomass was *Lamprothamnium macropogon*, with the remainder made up of *Lepilaena bilocularis* and *Ruppia maritima.* Lake Altibouka biomass showed a similar seasonal pattern but was dominated by *Lepilaena bilocularis* and *Nitella lhotzkyi.*

Different patterns of biomass production occurred depending on the variability of flooding regimes. In temporary systems with more variable flooding, macrophytes produced a rapid pulse of biomass. In permanent wetlands where water persisted, seasonal changes in biomass were pronounced. There are few published accounts of such seasonal biomass patterns co-existing with more obvious flood-pulse responses.

THE GROWTH AND SURVIVAL OF WESTERN KING PRAWNS *PENAEUS LATISULCATUS* IN POTASSIUM-FORTIFIED INLAND SALINE WATER.

Prangnell D.I., Fotedar R.

Muresk Institute, Curtin University of Technology, 1 Turner Ave, Bentley WA 6102 Australia. email: david.prangnell@student.curtin.edu.au

Inland saline water is plentiful in Western Australia but is often deficient in potassium (K^+) in comparison with marine water. A candidate species for culture in inland saline water is the western king prawn

(*Penaeus latisulcatus*). Previous research has shown that K fortification of inland saline water is essential for prawn survival and growth. However no research has been conducted on growing juvenile western king prawns in inland saline water. The present study was run to compare the growth and survival of western king prawns, from post-larval stage onwards, in potassium-fortified inland saline water and marine water.

A 6-month trial was conducted in twelve 250L closed systems. Fifty-six PL30 western king prawns were acclimated to 3 water types: inland saline water fortified to the same concentration of K^+ in marine water (IS100); inland saline water fortified to 80% marine water K^+ concentration (IS80); and marine water (MW), with 4 replicates of each water type. The inland saline water was from Wannamal, WA (31^o15"S, 116^o05"E). The salinity of all water types was reduced to and maintained at 32ppt using fresh water. Prawns were then reared for 6 months, being fed on crumble, pellets and live adult *Artemia*. Survival, feed intake and moulting were recorded daily, and 3 prawns per tank were measured weekly.

After 5 months survival was not significantly different (P>0.05) between water types, with IS100 having the highest survival of 86%. Mean prawn total weight, total length and carapace length were significantly higher (P<0.05) in MW than in IS100 and IS80. Mean prawn SGR (%weight gain/day) was 2.69 in MW, 2.60 in IS100 and 2.52 in IS80. Moult frequency and feed intake were significantly higher (P<0.05) in MW than in IS100 and IS80. These results indicate that early juvenile western king prawns can survive and grow in potassium-fortified inland saline water. However the slower growth rates and lower feed intake than prawns reared in marine water indicate the presence of other limiting factors.

Survival, growth and moult frequency of western king prawns after 5 months

Factor	IS100	IS80	MW
Survival (%)	86.0±2.2	75±6.5	80.0±5.7
SGR (%g/day)	2.60	2.52	2.69
Moult frequency	11.74±0.28	11.11±0.51	15.80±1.17
Final weight (g)	3.66±0.12	3.48±0.11	4.37±0.19

EXCHANGEABLE CATION IN LAKE QARUN SEDIMENTS, A CLOSED EGYPTIAN SALTY BASIN RECEIVING HUGE AMOUNTS OF DRAINAGE WATERS

-

-

Saad M.A.H., Hemeda E.I.

Oceanography Department, Faculty of Science, Alexandria University, Moharem Bey, Alexandria, Egypt

Lake Qarun is an enclosed salty basin lying in the arid region in the western Egyptian desert. Two peninsulas divide the lake into shallower eastern basin and deeper western basin. The area and volume of the lake vary according to its water level. The lake receives continuously the excess irrigation water from the agricultural fields through its two main drains; El-Bats and El-Wadi. The distribution of exchangeable cations was investigated in the lake sediments for the first time to illustrate their levels in the sediments as sinks of all elements and to correlate their concentrations with those in the lake water.

Sodium dominated potassium, giving means of 32.4 and 5.0 mg/g, respectively. Both cations showed lowest values in the vicinity of the main drain discharges at the eastern and southern lake sides and highest values in the lake middle, northern and western lake sides. Such distribution of sodium and potassium in the lake sediments followed that in the lake water. The effect of relatively poor drainage water in sodium and potassium on the southern region beside the consequent water turbulence in decreasing the adsorption ability of both cations on the silty clay sediments participated in decreasing the sodium and potassium contents in the sediments of this region. The sodium and potassium enrichment in the sediments of the lake center coincided with the higher interstitial water content of the sediments in this region. The horizontal distribution of Na: K ratios

showed a minimum in the middle and a maximum in the southern lake region. The eastern lake side gave a slightly lower Na: K ratio than the western side. The variability of these ratios might be due to concentrations of sodium in the remains of organisms incorporated in the lake sediments and / or the preferential increase in sodium feldspar than potassium feldspar.

Calcium ranked first and magnesium third in order of abundance among cations in the lake sediments. The distribution of both cations followed that of sodium and potassium. The relative decrease in calcium and magnesium in the sediments of the southern and eastern lake sides was accompanied with lower values in the overlying water column, following the direct effect of the drainage waters poor in these cations on these areas. The regional variations of calcium and magnesium in the lake sediments possibly coincided with the distribution of the light calcareous materials following water movements by wind actions. The Ca: Mg ratios showed a minimum in the southern region and a maximum in the northern area. The western lake side gave a noticeably lower ratio than the eastern side. The correlation coefficients between each of calcium and magnesium with the other major cations indicate highly significant relationships.

CALCIUM AS A KEY REGULATOR OF PHOSPHORUS AVAILABILITY IN PRAIRIE SALINE LAKES OF NORTH AMERICA

Saros J.E.,[1] Erickson J.M.[1], Wigdahl C.R.[1], Fritz S.C.[2], Osburn C.L.[3]

[1]University of Wisconsin-La Crosse, 1725 State Street, La Crosse, WI, 54601 USA. [2]University of Nebraska-Lincoln, Department of Geosciences, Lincoln, NE 68588 USA. [3]US Naval Research Laboratory, 4555 Overlook Ave SW, Washington DC 20375 USA

In prairie saline lakes of North America, total phosphorus (TP) concentrations are often high, frequently exceeding 100 µg/L. These systems typically do not follow the spring TP-chlorophyll *a* relationship observed in freshwater lakes, suggesting that phytoplankton in these systems may be limited by another factor, such as nitrogen or iron, but a pattern with these variables is also not evident. Alternatively, the pool of dissolved P in these lakes may not be readily bioavailable if it is bound to humic substances. To examine the latter hypothesis, we investigated phytoplankton productivity patterns in thirty lakes in the central and northern Great Plains in both early and late summer. Rates of alkaline phosphatase activity (APA) were measured along with a suite of nutrient and ionic parameters. The rate of APA was dependent upon calcium concentrations, such that high APA rates were never observed above 50 mg/L of calcium. This suggests that access to organically-bound P is limited in high calcium systems, and that patterns of primary production may become apparent if calcium concentration is included in multivariate models.

NITROGEN VERSUS PHOSPHORUS LIMITATION OF PHYTOPLANKTON IN SOLAR SALT PONDS

Segal R.D.[1], Waite A.M.[1], Hamilton D.P.[2]

[1]Centre for Water Research, University of Western Australia, Perth, Western Australia. [2]Centre for Biodiversity and Ecology Research, University of Waikato, Hamilton, New Zealand.

Nutrient limitation of phytoplankton was investigated in solar salt ponds at Useless Inlet in Western Australia. The ponds use solar energy to evaporate seawater for the purpose of commercial salt production. Comparisons of changes in dissolved inorganic nitrogen to phosphorus ratios and concentrations of dissolved inorganic nutrients against changes in concentrations of the conservative cation Mg^{2+}, indicated that

phytoplankton biomass was nitrogen limited along the entire pond salinity gradient. Nutrient addition bioassays indicated that in low salinity ponds (70-90 g kg^{-1}) phytoplankton were nitrogen limited but in high salinity ponds (110-140 g kg^{-1}), phosphorus limited. The differences between methods may be party due to isolation of phytoplankton in bioassay bottles from *in situ* conditions as well as from changes in phytoplankton species composition between ponds. The large proportion of dissolved organic nutrients in the water column, if available, may be a source of phytoplankton nutrition in these solar salt ponds. Dissolved organic nitrogen may be partially available for phytoplankton growth only in the low salinity ponds, potentially alleviating nitrogen limitation.

KEY FACTORS IN THE CONSERVATION OF SUBMERGED PLANT COMMUNITIES IN SECONDARY SALINISED WETLANDS

Sim L.L.[1], Davis J.A.[1], Chambers J.M.[1]

[1]Aquatic Ecosystems Research, School of Environmental Science, Murdoch University, South Street, Murdoch 6150, Western Australia

Secondary (anthropogenic) salinisation has affected large areas of land in Australia's southwest, causing aquatic ecosystems that were once fresh to become saline or hypersaline. The changes in salinity level have been accompanied by shifts in the biotic composition of these ecosystems, first with the loss of the freshwater submerged macrophyte community and associated fauna, and then, as salinities move higher, the loss of halophytic macrophytes. Despite the fact that some values have already been lost from the seasonally-drying wetlands of this region, the submerged plant community still plays an important structural and functional role, and its loss is likely to cause a dramatic decline in the complexity of the wetland food web. The results of this study suggest that salt tolerant submerged plants will no longer dominate seasonal wetlands above a threshold salinity, and that changes to other environmental factors such as hydrology may also drive the shifts in community dominance from macrophytes towards benthic microbial communities. Experimental observations and observational data were used to build a conceptual model representing the key biotic and abiotic drivers for change in secondary saline wetlands. This model provides a framework for decision-making about the management of wetlands in a salinising landscape.

DIETARY FLEXIBILITY OF WATERBIRDS ACROSS SALINITY AND DEPTH GRADIENTS IN SALT PONDS OF THE SAN FRANCISO BAY ESTUARY

Takekawa J.Y.[1], Athearn N.D.[1], Melcer D.T.[2], Miles A.K.[2], Schoellhamer D.H.[3]

[1]U. S. Geological Survey, Western Ecological Research Center, Vallejo, California USA. [2]U. S. Geological Survey, Western Ecological Research Center, Davis, California USA, [3]U. S. Geological Survey, California Water Science Center, Sacramento, California USA

Salt evaporation ponds have existed in San Francisco Bay, California for more than a century. In the past decade, most of the salt ponds have been retired from production and purchased for resource conservation with a focus on tidal marsh restoration. However, large numbers of waterbirds are found in salt ponds, especially during migration and wintering periods. The value of these hypersaline wetlands for waterbirds is not well understood, including how different avian foraging guilds use invertebrate prey resources at different salinities and depths. In this study, we examined the population number and diet of four feeding guilds of waterbirds across a salinity and depth gradient in former salt ponds of the Napa-Sonoma Marshes. Mean invertebrate

biomass varied widely from 1.4 g/m^2 at mid salinities to 97.1 g/m^2 at low salinity. Population counts were recorded within a 250m x 250 m grid system with known bathymetry to identify avian use by water depth. Although total invertebrate biomass and species richness was much higher in the lower salinity ponds, waterbirds fed in salt ponds up to very high salinities (250 ppt). American avocets (surface sweeper) foraged in shallow areas at pond edges and consumed a wide range of prey types (8) including seeds at low salinity (20 ppt), but preferred brine flies at mid salinity (40-80 ppt). Western sandpipers (prober) focused on exposed edges and shoal habitats and consumed only a few prey types (2-4) at both low and mid salinities. Suitable depths for foraging was greatest for ruddy ducks (diving benthivore) that consumed a wide variety of invertebrate taxa (5) at low salinity, but focused on fewer prey (3) at mid salinity. We found that dietary flexibility allows different guilds to use ponds of different salinities, but that foraging extent is limited by available water depths.

OSMOREGULATORY MECHANISM AND GROWTH OF BLACK TIGER PRAWN *(PENAEUS MONODON* Fabricius, 1798*)* REARED IN FORTIFIED INLAND SALINE WATER

Tantulo U.[1], Fotedar R.[1]

[1]Muresk Institute, Curtin University of Technology, Perth, WA.

Past research has indicated that fortification of inland saline water (ISW) with potassium ion (K^+) is essential for black tiger prawn (*Penaeus monodon*) survival and growth. However, it is not clear whether concentration of K^+ alone or its proportion with other mono-valent and divalent ions in ISW makes it important. A trial for 28 days was conducted to investigate the effect of K^+ concentration on various physiological responses of *P. monodon* (2.5 ± 0.1 g). These responses include osmoregulatory capacity, iso-osmotic point, specific growth rate (SGR) and food conversion ratio (FCR). Different concentrations of K^+ were used by testing three salinities (5, 25 and 45 ppt) in two water types. Two water types tested were inland saline water fortified with 100% of K^+ concentration of ocean water (ISW_{100}) and raw ocean water (OW). Different salinities indicate different proportion of K^+ while keeping its ratio with other ions constant. Two water types at same salinity indicate same K^+ concentration but its different ratios with other ions present in that water type.

At the end of the trial, water type did not influence SGR's of *P. monodon*, however, both water types resulted in higher SGR at 25 ppt. Osmoregulatory capacity (OC) of *P. monodon* increased significantly *($P < 0.05$)* in ISW_{100} from 5 to 45 ppt while it remained the same between 5 and 25 ppt of OW.

Relationship between serum osmolality and medium osmolality resulted in low slope values ranging from 0.12 to 0.18 in ISW_{100} and 0.11 to 0.16 in OW. The iso-osmotic point of *P. monodon* in ISW_{100} ranged from 22 to 25 ppt and 21.5 to 24.5 ppt in OW indicating that the *P. monodon* osmoregulate efficiently in both water types. Comparing our result with the past research suggest that 100% fortification of K^+ in ISW improves the osmoregulatory efficiency and growth rates of *P. monodon.* By comparing the results from ISW_{100} and OW, it is evident that K^+ alone play a major role in osmoregulatory mechanism and SGR's of *P. monodon*. Future study is required to quantify the ratios between K^+ and other mono and divalent ions that can have an important bearing on the culture performance and osmoregulatory efficiency of *P. monodon*.

DEVELOPMENT OF A DIATOM-BASED TRANSFER FUNCTION FOR LAKES AND STREAMS IMPACTED BY SECONDARY SALINISATION IN THE SOUTH-WEST OF WESTERN AUSTRALIA.

Taukulis F.E.[1], John J.[1]

[1]Department of Environmental Biology, Curtin University of Technology, U1987, Perth 6845, Western Australia.

One of the most important water resource management issues in Western Australia is secondary salinisation, resulting from dryland agriculture. Extensive land clearing practices have led to the mobilisation of salts previously stored in the soil profile. Subsequent saline runnoff increases the salinity level of lakes and streams, adversely affecting aquatic biota. The microalgae diatoms are ideal organisms that can be used to monitor this problem by determining species tolerance limits. In Western Australia little research has been carried out into the preference of diatoms to varying salt loads. The objective of this project was to develop a diatom-based transfer function that provides a predictive tool to determine future salinity trends based on changes in community structure.

A total of 95 study sites from the south-west region of Western Australia were included in the sampling regime. The multivariate statistical technique of canonical correspondence analysis (CCA) was used to explore the relationship between water quality and diatoms. Salinity was shown to be the most important factor influencing species composition, accounting for the most variation in the data. Weighted averaging (WA) was used to generate a diatom-based transfer function for salinity with $r^2 = 0.90$ and $r^2_{bootstrapped} = 0.75$. Comparison with other models indicated that the transfer function performed very well, and could be applied as a reconstructive tool to infer the past salinity history of wetlands. However, the main focus of the research is on the use of the model to predict future salinity changes in particular catchment areas. Shifts in diatom species composition could be used to detect increasing salt concentrations as well as assess the effectiveness of rehabilitation measures. This type of model aims to be incorporated into long-term monitoring programs, preventing further deterioration in the water quality of lakes and streams in the south-west of WA.

SULFIDE IRRUPTIONS AND GYPSUM BLOOMS IN THE SALTON SEA AS DETECTED BY SATELLITE IMAGERY, 1979-2004

Tiffany M.A.[1], Dainer J.S.[1], Detwiler P.M.[1], Dexter D.M.[1], González M.R.[2], Moreau M.F.[1], Reifel K.M.[1], Swan B.K.[1], Watts J.M.[1], Ustin S.L.[3], Hurlbert S.H.[1]

[1]Center for Inland Waters, Department of Biology, San Diego State University, San Diego CA USA. [2] Centro de Investigación Científica y de Educación Superior de Ensenada, Ensenada, Baja California, Mexico.
[3]Department of Land, Air and Water, University of California, Davis, Davis CA USA.

For decades satellite sensors, fishermen, and shoreline residents have detected so-called "green tides" at the Salton Sea. Usually attributed to algal blooms, these are in fact due to microscopic suspended gypsum crystals, which were first recorded, at densities of 30 crystals per ml of surface water, in September 2000. Formed when sulfide-rich bottom waters mix into oxygen-rich surface waters, the crystals give a bright signal, especially in the green waveband, and serve as an indicator of these sulfide irruptions. Such gypsum blooms have been observed by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) sensor every year during 1998-2004, generally in summer to early fall and in mid-lake, and lasting days to a week or more. The events date back to at least 1979 when they were documented by the Coastal Zone Color Scanner (CZCS). Their occurrence has been accompanied by documented mass mortalities of phytoplankton, zooplankton, and fish. Occasional shoreward advection of the anoxic, sulfide-rich water masses presumably causes mass mortalities of nearshore benthos (pileworms, amphipods and barnacles) and fish fry. In 2003, gypsum blooms started early, at the end of

May and, due to Santa Ana conditions in October, did not let up until November, but their duration is more typically a few days.

A STUDY OF SALT LAKES AND SPRINGS OF EYRE PENINSULA, SOUTH AUSTRALIA.

Timms, B.V.

School of Environmental and Life Sciences, University of Newcastle, Callaghan, NSW 2308, Australia. Email: brian.timms@newcastle.edu.au

An 18 month's study of 40 saline wetlands, ranging from 6-336 gL^{-1}, on the west and southern coasts of Eyre Peninsula yielded 84 species of invertebrates, some aquatic plants and a fish. Invertebrates are taxonomically diverse and include 36 crustaceans, 28 insects, 12 molluscs and significantly, an aquatic spider, two polychaetes, two sea anemones, a sponge and a bryzoan. Most are tolerant of wide fluctuations in salinity, so that there are 48 halobionts, 20 halophils and only 16 salt-tolerant freshwater species. Many invertebrates are restricted to the thalassic springs where marine gastropods dominate. Athalassic wetlands are dominated by crustaceans *Parartemia cylindrifera, Daphnia truncata, Calamoecia salina, Metacyclops* near *arnaudi, Diacypris* spp., *Australocypris* spp. and *Haloniscus searlei*, and are of two basic types – coastal and continental. Continental wetlands are subdividable on a salinity gradient and some are separable because of a minor influence of marine spring water. There is evidence of coastal wetlands evolving biologically into the continental type, and for some lakes to be still in transition. There is also evidence of increasing salinities in recent decades and already two lakes are severely secondarily salinised. Like other salt lakes in Australia, the fauna is regionally distinctive, but a little less so now that the fauna is better known.

THE GEOMORPHOLOGY AND HYDROLOGY OF SALINE LAKES OF THE MIDDLE PAROO, ARID-ZONE AUSTRALIA.

Timms, B.V.

School of Environmental and Life Sciences, University of Newcastle, Callahgan, NSW 2308, Australia. Email: brian.timms@newcastle.edu.au

The middle Paroo catchment of northwest New South Wales and southwest Queensland has numerous lakes, some of which are saline or become saline as they dry. Eleven lakes have been mapped and these plus five others have been studied for periods of up to 18 years. Many were formed by dunes blocking drainage routes, some lie in dune swales, some lie at the less sedimented edge of the Paroo floodplain, and Lake Wyara lies on a faultline. All developed further by deflation and owe their form to wind-induced currents and wave action shaping shorelines. Typically, lakes are flat-floored and shallow (<2 m deep) but some have with maximum depths ~ 6.5 m. Most saline lakes have shrunk as a result of multiple lunettes forming on the eastern shore, and many larger ones have migrated westwards due to wave action on cliffs on the western shore. Lakes of low salinity have sandy beaches and no, or poorly developed lunettes, but may be compartmentalised by spit growth across bays. Lakes with N-S axes have the southeastern corner cut-off by spits generated by currents induced by northwesterley winds. Many lakes are filling with sediment derived from the overgrazing of catchments associated with European settlement. In small eroded catchments, sediments are sticky red clays which accumulate and are filling the lakes, but if the added sediments come from large, less eroded, catchments, they are friable and present deflation can keep pace with sedimentation, so that such lakes are not infilling.

Larger lakes with inflowing streams fill in El Niño years, then dry over the next few years, i.e. are

episodic. Smaller lakes without surface inflows may fill a few times in wet years but dry quickly. Most lakes remain dry in La Nina years, but those with major inflowing streams get occasional small inflows which evaporate within months. Salinity regimes fluctuate between subsaline (1-3 gL^{-1}) and euhypersaline > 200 gL^{-1} and, while instantaneous faunal lists may be depauperate, cumulative species lists can be long. On the other hand lakes which normally are fresh, but become saline in their final stage of drying, develop only a limited saline lake fauna.

RESPONSE OF FRINGING VEGETATION TO FLOODING AND DISCHARGE OF HYPERSALINE WATER AT LAKE AUSTIN, A LARGE SALT LAKE OF ARID AUSTRALIA.

van Etten E.J., Vellekoop S.J.

Centre for Ecosystem Management, School of Natural Sciences, Edith Cowan University, 100 Joondalup Drive, Joondalup, Perth 6027, Australia.

Little is known about the patterns and dynamics of the saltmarsh vegetation which surrounds many of the salt lake systems of arid/semi-arid Australia. Lake Austin is a very large salt lake with extensive areas of fringing saltmarsh; it is located in the arid Murchison Region of Western Australia. In this study, the changes in this vegetation over a four year period (1998-2002), during which both a major flooding event and addition of hypersaline groundwater from a nearby mining operation occurred, are reported. The monitoring program, based on BACI (Before-After-Control-Impact) principles, was designed to detect impacts of discharging hypersaline water into the lake, however the flooding event, the result of above average rainfall in early 2000, have complicated the results. The rains of 2000 and subsequent inundation of the vegetation immediately fringing the lakebed and major inlet channels, resulted in dramatic changes to the species composition of annual and short-lived species and growth of perennial species. Flooding resulted in substantial death and damage to perennial shrubs (particularly *Halosarcia fimbriata*) due most likely to a combination of several weeks/months of inundation and smothering by macroalgae and *Ruppia*, with smaller plants and those closer to the lakebed impacted upon to a greater degree. Seed germination and recruitment of new *Halosarcia* plants was substantial as floodwaters receded with the majority of these seedlings surviving some two years after flooding despite the severe drought which followed the flood. Growth rates of seedlings differed substantially and were linked to subtle differences in micro-topography. Recruitment following flooding was also demonstrated in *in-vitro* experiments involving inundated soil cores, however only when water was relatively non saline (conductivity < 30 mS/cm). A conceptual model is proposed to explain changes in fringing vegetation in response to frequency, depth, period and salinity of flooding in relation to micro-topography. Despite the profound effect of flooding, impacts of discharge were identified with changes in topsoil pH and salinity greater in areas closer to the discharge than those further away. Impacts on vegetation characteristics were not detected however; possible reasons for this are discussed. Environmental management implications of discharging unwanted mine-pit water to salt lakes, now a common practice in the arid Australia, area also explored.

LIFE HISTORY VARIATION EXHIBITED BY THE COPEPOD *CALAMOECIA CLITELLATA* FROM WESTERN AUSTRALIAN SALT LAKES.

Whitehead A.

School of Animal Biology (M092), The University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009. E-mail: ayesha@graduate.uwa.edu.au

The copepod *Calamoecia clitellata* is endemic to Australian salt lakes, and occupies spatially heterogeneous habitats with regards to salinity. Despite its widespread distribution, relatively little is known of how its life history varies with environment. In this paper I describe how broad aspects of life history and specific life history traits in *C. clitellata* vary spatially and temporally with physical and chemical attributes of

environment. Four temporary populations were examined in salt lakes in Western Australia, two of high salinity (60-90 g L^{-1}) and two of low salinity (15-30 g L^{-1}). Populations were sampled fortnightly, from when nauplii first emerged from resting eggs to when the population returned to a dormant state.

Consistent temporal trends were observed amongst populations of *C. clitellata*. Emergence of nauplii coincided with lowered salinities and temperatures experienced during filling of the lakes. Two distinct phases of egg production were evident during the course of the hydrocycle. Subitaneous egg production by females was characteristic of when lakes were full and chemical and physical aspects of environment were relatively stable. During this phase of egg production, body sizes of ovigerous females progressively decreased, as did the number of eggs per clutch, and egg volume and overall clutch volume increased. A switch to resting egg production occurred with environmental changes associated with the onset of drying of the lakes, accompanied by a progressive increase in clutch size and overall clutch volume. These results suggest that*C. clitellata* individuals inhabiting different environments are subject to similar constraints over time and respond to these through life history in a similar manner.

Marked interpopulation variation in life history traits was observed for both types of egg production in *C. clitellata*. Ovigerous females from high salinity lakes tended to be larger, produce clutches with more and larger eggs per clutch and larger overall clutch volumes than those from low salinity lakes. These results raise the question of whether such variation represents adaptive/genetic divergence of traits or phenotype plasticity. It can be concluded from this study that *C. clitellata* has evolved reproductive strategies to suit different environments on both temporal and spatial scales.

SEVERE EUTROPHICATION AND FOOD WEB DYNAMICS OF AN URBAN EMBAYMENT OF THE GREAT SALT LAKE, UTAH, USA

Wurtsbaugh W.A., Marcarelli A.M.

-

-

Aquatic, Watershed & Earth Resources Department and the Ecology Center, Utah State University, USA

The Great Salt Lake of Utah is surrounded on its eastern and southern shores by 1.4 million people, with projections of 5 million by 2050. Domestic, agricultural and industrial wastes from this population flow primarily into Farmington Bay, a shallow, 280-km^2 "estuary". Surface water salinities there range from 0.5 – 9%, but a 16% salt wedge often enters from the main lake. Excessive nutrient loading into the bay causes hypereutrophic conditions: Secchi depths are <0.25 m, Chl. *a* >>100 µg/L, TP >600 µg/L, TN >7500 µg/L, and there are massive blooms of nitrogen-fixing cyanobacteria, primarily *Nodularia*. Anoxic and reducing conditions within the salt wedge produce H_2S concentrations >8 mg/L and when windstorms mix this H_2S into the overlying water, the entire water column may go anoxic for >2 d. Brine shrimp densities >10/L can ameliorate (Secchi >1 m) the hypereutrophic conditions, but these grazers are rarely abundant, due either to predation from corixids and harpacticoid copepods, or to the severe water quality in the bay. Seasonal and inter-annual changes in salinity also influences eutrophication, because at salinities >6%, cyanobacteria can no longer fix nitrogen. Prehistoric stromatolites are abundant in the bay, but are now shaded by the excessive phytoplankton growth. The eutrophication is discussed relative to the socio-political climate that until recently has largely neglected water quality issues in North America's largest salt lake.

HYDROCHEMICAL CHARACTERISTICS OF SALT LAKES ON THE QINGHAI-TIBET, CHINA

Zheng M.P., Liu X.F.

R & D Center for Saline Lake and Epithermal Deposit; Open Laboratory of Saline Lake Resources and Environment, Chinese Academy of Geological Sciences, Beijing 100037, China

Located at the east end of the global northern hemisphere salt lake belt, the Qinghai-Tibet Plateau salt lake region is the highest salt lake region in the world and attracts the world with its special composition of salt lake waters and the great number of salt lakes. The senior author began to undertake salt lake investigation and research in the region in 1956. Up to now a total of 550 results of hydrochemical analyses have been obtained. On that basis, combined with the tectonic characteristics of the plateau, the hydrochemical characteristics of the salt lakes in the region are discussed.

The salinity of lakes on the Qinghai-Tibet Plateau is closely related to the natural environment and particularly the climatic conditions for the lake evolution. According to the vast number of the lakes and interpretation of satellite images, the salinity of the lakes in the region has a general trend of decrease from north and northwest to south and southeast, showing a synchronous variation with the annual aridity (annual evaporation/annual precipitation) of the modern plateau. For example, the aridity of the Qaidam basin in the northern part of the plateau may reach 100 and the average salinity of 28 salt lakes in the basin is 312.33 g/L; whereas the aridity in the southern part of the plateau is 6–10 and the average salinity of 33 salt lakes in this area is 157 g/L.

The pH values of the plateau lakes are related to the hydrochemical types and also to the salinity of the lake waters, i.e. the pH values of the lakes decrease from the carbonate type→sodium sulfate subtype→magnesium sulfate subtype→chloride type and are generally negatively correlated with the salinity.

Both geoscience and biology both take the main ions in salt lakes as the basis for the classification of hydrochemical types of salt lakes. The common ions in salt lakes are Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-} SO_4^{2-}, CO_3^{2-} and HCO_3^{-}. In this paper, according to the Kurnakov-Varyashko classification the salt lakes are divided into the chloride type, magnesium sulfate subtype, sodium sulfate subtype and carbonate type, and according to different total alkalinities ($K_C=Na_2CO_3+NaHCO_3/\Sigma salts\times 100\%$) and different saline mineral assemblages, the carbonate type is further divided into three subtypes, namely, the strong carbonate subtype, moderate carbonate subtype and weak carbonate subtypes.

According to the above-mentioned hydrochemical classification, the waters of the plateau salt lakes are classified intensively. From south to north four hydrothermal zones and one area may be distinguished; they are the southern Tibet low-salinity carbonate type subzone (I_1), southern Qiangtang high-salinity carbonate type subzone (I_2), northern Qiangtang sodium sulfate subtype zone (II), Kunlun-Hoh Xil magnesium sulfate subtype zone (III) and Kumkol-Qaidam chloride-sulfate type zone (IV), and sodium sulfate discharge area.

At present 56 elements have been detected in lake waters of the Qinghai-Tibet Plateau, of which the concentrations of Na, K, Mg, Ca and Cl and SO_4^{2-}, CO_3^{2-} and HCO_3^{-} ions are highest. However, compared with the hydrochemical compositions of other salt lake types, the plateau salt lakes, especially those in the southern Qiangtang carbonate type subzone (I_2), contain high concentration of Li, B, Cs and Rb, and there are also As, U and Br anomalies in local areas.

In the plateau lake waters, B is intimately associated with Li, Cs, K and Rb and its concentration shows a general positive correlation with the increase in salinity of the lake waters. The highest positive anomalies of B, Li, Cs and K center on the Ngangla Ringco district in the western segment of the southern Qiangtang carbonate type subzone (I_2) and coincide with the high-value area of hot spring B, Li and Cs in the region. The above strongly suggests that the materials containing special elements such as B, Li and Cs are related to the sources of hydrothermal waters at depth. According to recent geophysical and volcanic geochemical studies, the hydrothermal waters in this region had close genetic relation to anatectic magmatism resulting from India-Eurasia continent-continent collision and the B-Li (-Ce) salt lakes in the Cordillera Plateau of South America just originated on active continental margins, both of which indicate that global specific active tectonics was the main cause responsible for the high concentrations of B, Li, Cs (K and Rb) in natural water and their mineralization.

POSTER PRESENTATIONS

A MULTIVARIATE ANALYSIS OF SELENIUM DISTRIBUTION IN NEARSHORE SEDIMENTS OF THE SALTON SEA WITH IMPLICATIONS FOR RESTORATION PLANNING.

Barnum D.A.[1], Scheidlinger C.[2], Chesnut J.[2]

[1]U.S. Geological Survey, La Quinta, CA USA. [2]Agrarian Research and Management. Bishop, CA USA

During 2003 we collected and analyze nearshore sediments of the Salton Sea samples paricle size, silt/sand/clay ratios, and organic matter content as part of an air quality assessment.. More than 600 samples of sediment were collected along transects at 5, 10, and 15 foot water depths. Following this analysis, all remaining sediment residues were held intact as archived material. We then identified a subset of more than 200 of these archived samples and submitted them for selenium analysis. The results of this analysis indicates a strong correlation between selenium and organic matter (r^2 = 0.66, mean = 2.0 µg/g, geometric mean = 1.6 µ/g, range 0.2-7.1 µg/g). Areas of high organic matter around the mouths of rivers exhibit higher concentrations of selenium and may pose problems for restoration actions, particularly with respect to location and functioning of wildlife habitats.

SMALL PLAYAS OF THE YARRA YARRA DRAINAGE SYSTEM, WESTERN AUSTRALIA: SOME FEATURES OF THEIR GEOMORPHOLOGY, HYDROLOGY AND DIATOM ECOLOGY.

Boggs D.A.[1], Boggs G.S.[2], Eliot I.[1], Knott B.[3]

[1]School of Earth and Geographical Sciences. The University of Western Australia, 35 Stirling Highway, Crawley Western Australia, 6009. [2]GIS and Remote Sensing Group. Building 18, Charles Darwin University, Casuarina, Northern Territory, Australia, 0909. [3]School of Animal Biology. The University of Western Australia, 35 Stirling Highway, Crawley Western Australia, 6009.

Small playas (< 10 hectares) constitute over half of the playas in the Yarra Yarra drainage system of Western Australia. This paper reports on investigations into the geomorphology, hydrology and diatom ecology of small playas in the system, undertaken during the period from February 2002 to June 2004.

PRELIMINARY GEOLOGY, GEOCHEMISTRY, AND BIOLOGY OF ACID SALINE LAKES IN WESTERN AUSTRALIA AND VICTORIA

Bowen B.B.[1], Benison K.C.[1], Mormile M.R.[2], Oboh-Ikenobe F.E.[3]

[1]Department of Geology, Central Michigan University, Mt. Pleasant, Michigan, U.S.A. [2]Department of Biology, University of Missouri, Rolla, Missouri, U.S.A. [3]Department of Geological Sciences and Engineering, University of Missouri, Rolla, Missouri, U.S.A.

Acid saline lakes exist in southern Western Australia and in northwestern Victoria. Here we present preliminary results of an investigation of their geology, geochemistry, and biology. We studied these lakes in July-August, 2001 and again in June–July, 2005.

In southern Western Australia, acid saline lakes are situated on highly-weathered, usually quartz-rich, metamorphic bedrock. In many of these lakes, thin beds of red hematite and quartz sands and muds overlie the bedrock. Most lake beds are composed of hard, 1-20 cm-thick crusts of gypsum and/or halite, overlying this soft, red mud. Lake waters are usually less than 0.5 m deep and many undergo desiccation seasonally. Lake waters have pHs of 2 – 4, are saline (TDS >100‰), and are Na-Mg-Ca-Cl-SO_4-Br-rich. Lake waters precipitate halite, gypsum, hematite, and small amounts of jarosite and alunite. Surrounding the lakes are mudflats and sandflats, hosting mudcracks, ripple marks, and mm-thick evaporite crusts. Groundwaters under these mudflats and sandflats have similar geochemistry as the lake waters. They precipitate displacive crystals of gypsum, as well as fine hematite, halite, and jarosite. Also surrounding the lakes are sheet flood deposits and their small ephemeral channels which contain sand and gravel carried into the lakes during times of flooding. Sparsely-vegetated, small sand dunes composed of hematite-coated quartz sand grains are near many of the lakes.

In northwestern Victoria, the acid saline lakes such as Lake Tyrrell and the Pink Lakes have a different geological setting, a slightly different chemical composition, but a similar mineral assemblage. The lakes are situated on a thick package of sediments and sedimentary rocks, including clays, sandstones, and coal. The lakes are slightly deeper, slightly less saline, and slightly less acidic. Lake waters precipitate halite. Groundwaters precipitate halite, gypsum, hematite, and smaller amounts of jarosite and alunite.

Preliminary biological work includes field observation of plants and animals and laboratory identification of microorganisms. Animals seem to stay away from these environments, judging from the lack of bird, kangaroo, dingo, and emu tracks at the acid lakes, despite the presence of abundant tracks of these animals at nearby neutral saline lakes. Plants were present, but not diverse, at the acid saline lakes. Organic residues of lake sediments show *Bottryococcus*-like structures, suggesting freshwater algae. In addition, an enrichment culture prepared from Lake Tyrrell halite contains rod and cocci-rod shaped microorganisms. DNA from this culture has been extracted and the 16S rRNA genes were amplified. A preliminary clone library was developed. The inserted 16S gene of five of the clones was sequenced. Each clone was found to be unique and to be closely related to other bacteria from saline, sulfate-rich environments.

ESTABLISHING A CASE FOR A METABOLIC ISLAND IN THE GREAT SALT LAKE, UTAH, USA.

Breakwell D.P., Barker E.M., Johnson M.D., Harker A.R.

Department of Microbiology and Molecular Biology, Brigham Young University, Provo, Utah 84602, USA

The Great Salt Lake is a somewhat shallow, hypersaline, thalassohaline ecosystem and historically it has been thought to be fairly chemically and biologically homogeneous. However, the lake does contain a variety of unique environments that have not been systematically investigated. Rozel Point is one of these sites and a petroleum seep is located there. Examination of the microbial diversity and the enzymatic processes associated with communities of organisms in this extreme environment may give insights into spatial patterns of biodiversity and ecological heterogeneity not expected in Great Salt Lake. Our hypothesis was that a chemical gradient associated with the seep has created a metabolic and genetic “island” that is occupied by distinct and unique microbial communities. To establish a basis for a metabolic island, sediment samples were taken in transect from the main seep. As expected, there was a hydrocarbon gradient away from the seep and petroleum constituent profiles for the transect samples will be reported. As a general indicator of metabolic activity, we measured dehydrogenase activity. Our results indicate 12 times greater activity at the center and a linear decline to background levels within 200 meters away from the seep. Biomass, alkaline phosphatase, and arylsulfatase activity for transect samples will also be reported.

STRUCTURAL-FUNCTIONAL COMPONENTS OF THE PLANKTON COMMUNITY IN THE

ECOSYSTEM OF SHIRA LAKE (REVIEW AND EXPERIMENTS)

Degermendzhy N.N.

Krasnoyarsk State Medical Academy, P. Zheleznyak Str., 1, Krasnoyarsk 660022, Russia (E-mail: ibp@ibp.ru)

The work is dedicated to a study of plankton organisms of Lake Shira in the form of a review of the data of field observations and obtaining kinetic characteristics. The main microbiological characteristics of bacterioplankton are estimated by seasons and by stations. Special experiments with isolated groups of microorganisms have been carried out for estimation of growth rates and their dependence on limiting substrates. The phytoplankton species composition has been established. Experiments on study of the effect of mineralization on the growth and species composition of the phytoplankton have demonstrated that at an elevated mineralization (including increase of the amount of biogens) development of diatoms takes place. This is confirmed both by the quantitative characteristics of their number and biomass and by the control of the physiological state of cells. At a lowered mineralization, the algae increment takes place mainly due to the species of the genus Microcystis both on the surface and at the depth 1Zb. GENERAL CONCLUSIONS: 1.1. An abnormal dynamics of the total abundance of bacterioplankton in Shira lake in winter has been established: in winter 1988-2004, the abundance exceeded that in summer season. The main microbiological characteristics of bacterioplankton by seasons and stations have been determined. 1.2. For the first time, the main physiological groups of the lake microorganisms have been isolated: heterotrophs, denitrifiers, aerobic cellulose-destroying, phosphoric, and desulphurating bacteria. Their average abundances in the lake have been estimated. 1.3. Special "acute" experiments on the detached microorganism groups were carried out for estimation of growth rates and of their dependence on the limiting substrates. Kinetic characteristics of the heterotrophs and phosphoric bacteria have been obtained. 2.1. At a 2-fold increased mineralization level in the phytoplankton community, *Cyclotella tuberculata* actively develops, wherein the community is the most resistant to photoinhibition. 2.2. At a lowered mineralization level, the increment takes place due to development of blue-green algae, in particular species from *Microcystis* genus. 3.1. The dominant zooplankton species - *Arctodiaptomus salinus* - consumes all mass microalgae species: *Lyngbya contorta*, *Microcystis* sp., *Dictyosphaerium* sp., and *Oocystis* sp., with the exception of *Cyclotella* sp.

COMMUNITY AND SPECIES-LEVEL PATTERNS IN ALKALINE PHOSPHATASE ACTIVITY IN SALINE LAKES IN NORTH AMERICA

Erickson J.M., Saros J.E., Martin C.S.

University of Wisconsin-La Crosse, 1725 State Street, La Crosse, WI, 54601 USA

The factors that control primary productivity patterns in saline lakes are unclear. While the spring total phosphorus-chlorophyll *a* relationship developed for freshwater lakes is not observed in these lakes, more precise indicators of phosphorus limitation may reveal patterns in these systems. A suite of lakes located in the Great Plains of North America were sampled during May and August 2004. These lakes varied in salinity, ionic composition, and nutrient concentrations. To investigate phosphorus limitation, we measured the amount of alkaline phosphatase activity (APA) in these lakes. Coupled with enzyme labelled fluorescence (ELF) of alkaline phosphatase, species-level phosphorus stress could be determined based on a qualitative analysis. *Fragilaria crotonensis* was abundant across lakes in May, while *Aphanizomenon* sp. were widespread in August. *Gloeocapsa* sp. were abundant in both months. From the lakes that had a high level of activity, every species contributed to total APA. At least one species from each of the Cyanophyta, Bacillariophyta, Chlorophyta, and Dinophyta exhibited APA. The key contributors to the bulk APA rate were typically the dominant taxa in a given sample.

Together both methods provide a more concise assessment of phosphorus limitation and a better resolution of limitation patterns not only between lakes but also of the species in each individual lake.

SURVIVAL, GROWTH AND CONDITION INDEX OF PINK SNAPPER,*PAGRUS ORATUS* (BLOCH & SCHNEIDER, 1801) LARVAE AND JUVENILE WHEN CULTURED IN INLAND SALINE WATER AND IONICALLY FORTIFIED INLAND SALINE WATER.

Fotedar R.[1], Prangnell D.[1], Longbottom S.[1], Morrell B.[1], Johnson B.[1]

[1]Muresk Institute, Curtin University of Technology, 1 Turner Avenue, Bentley, WA 6102 Australia, email: r.fotedar@curtin.edu.au

Inland saline water (ISW) has been recognised as an alternative potential resource to culture marine species. Two independent trials involving snapper (*Pagarus auratus*) larvae and juveniles respectively were conducted to investigate the technical feasibility of using ISW to culture the species. The ISW used in these trials was sourced from Lake Albon in Goomalling, Western Australia. The ionic profile of ISW showed that it had significantly lower concentrations of calcium and potassium ions as compared to ocean water (OW) of the same salinity.

In the first trial, the impact of ISW at 15, 25 and 35 ppt on larval survival, growth, and morphometric measurements was investigated and compared to OW of the same salinities. The results showed that the survival of snapper larvae reared in ISW at higher salinities was significantly lower than those reared in OW. Morphological development of larvae was not influenced by any water type. Further investigation revealed that the presence of luminescent bacteria in ISW was responsible for higher mortalities and concentration of toxins produces by these bacteria was directly proportional to the salinity levels.

In the second trial three culture media at 22 ppt viz. OW, ISW and ISW with calcium and potassium salts added to equate to levels found in ocean water (ISWf) were tested to culture snapper juveniles for 60 days. The survival and growth rates were similar when juveniles were cultured in OW and ISWf and significantly higher than when they were cultured in ISW. The condition indices of snapper juveniles did not change when cultured in any water type.

These results demonstrate that inland saline water, with potassium and calcium added, is likely to produce similar growth and survival to ocean water for snapper juveniles.

BIOSYSTHEMATICS STUDY ON KALE-SHOUR BRINE SHRIMP (*ARTEMIA*) WITH EMPHASIS ON CYTOGENETICS AND MORPHOMETRIC

Ghassemzadeh F.[1,2], Banihashemi S.A.[1], Darvish J.[1], Haddad F.[1]

[1]Department of Biology, Faculty of Sciences, Ferdowsi University of Mashhad, Iran. [2]Department of Biology, Faculty of Sciences, Azad Mashhad University, Mashhad, Iran. fghassemzadeh@science1.um.ac.ir

Brine shrimp *Artemia* are present in saline and hypersaline ecosystems including Urmia lake and Kale-shour in Iran. In this study, cytogenetics and morphometric charcteristics of previously unidentified *Artemia* in

Kale-shour were compared to *Artemia urmiana*, Gunter and *A. parthenogenetica* from Urmia Lake. Kale-shour is a hypersaline ecosystem located 35 km north of Gonabad in the Khorasan Province in Iran and could be suitable for *Artemia* aquaculture industry in the region. *Artemia* collected from the study area were compared with two other populations from Urmia Lake in northwest Iran. Cytogenetic studies from nauplii, instar1, showed that the population of Kale-shour is diploid (2n=42). Eight morphometric characteristics were studied from samples of Urmia Lake and *Aremia* collected from the study area. Cysts were cultured separately in a 20L aquarium under constant environmental conditions (salinity 62 ppt, temperature 20±1C°, pH≈ 8, constant aeration, fluorescent light 40 cm from aquarium surface). These cultures fed with rice bran and unicellular algae. After 35 days, a random sample of about 30 females from each culture were anaesthetized in chloroform and eight quantitative characteristics (total length, abdominal length, abdominal width, width of head, distance between complex eyes, maximal diameter of complex eye diameter, length of furca and length of the first antenna) were measured to the nearest 0.001 mm. Data was analyzed using the statistical software SPSS 10 and multivariate analysis, with results showing that Kale-shour *Artemia* are significantly different from *Artemia urmiana* . However, Kale-shour *Artemia* and *A. parthenogenetica* are identical. Thus, Kale-shour *Artemia* could belong to *A. parthenogenetica* species. This species tolerates a broader range of salinities and will help with allocation of *Artemia* resources for aquaculture in the region.

MICROBIAL MATS IN SALT LAKES OF ROTTNEST ISLAND, WESTERN AUSTRALIA AS MONITORING TOOLS

Hay M., John J.

Department of Environmental Biology, Curtin University of Technology, GPO Box U 1987 Perth, WA 6845

Six permanent and several smaller temporary Salt lakes cover 10% of Rottnest Island (1,900 ha) separated from the mainland by 23 Km. They range from brackish to hypersaline and are important ecosystems providing habitat and breeding areas for hundreds of vagrant migratory bird species as well as native species. Microbial mats are abundant in these lakes and are the predominant primary producers of the lakes. The species diversity and composition of the mats vary from lake to lake and can be related to depth and volume of water as well as the water chemistry, including salinity and nutrient levels. The composition of the mats were first studied by John in 1981. Further studies on the algal mats commenced in 2005 with the objective of investigating any possible links with the integrity of the microbial mats with nutrient loading. Samples were taken from Government House, Herschell, Serpentine and Garden Lakes, which display an average summer salinity of 110, 109, 100 and 77 ppt respectively were analysed for structure (cohesiveness) and species composition. The microbial mats differ in thickness and composition within each lake as well as between lakes. The microbial communities are predominantly composed of bacteria, diatoms and cyanobacteria

The species recorded from these lakes contain predominantly coccoid and filamentous types of cyanobacteria and include *Aphanothece halophytica, Anacystis marina, Anacystis dimidiata, Agmenellum thermale, Oscillatoria princeps, Microcoleus Lyngbaceus, Spirulina subsalsa, Spirulina subtilissima and Schizothrix calcicola.* 29 diatom species have been recorded, including *Amphora coffeaeformis, Nitzschia communis, Nitzchia rostellata* and a *Navicula* species, which are found in all of the lakes but in different relative abundance. Based upon the composition of the mats and water chemistry, one of the lakes –Garden Lake appeared to show symptoms of degradation.

IRON LIMITATION PATTERNS IN PRAIRIE SALINE LAKES OF THE NORTHERN GREAT PLAINS OF NORTH AMERICA.

Henke M.[1], Saros J.E.[1], McKay, R.M.[2]

[1]University of Wisconsin-La Crosse, 1725 State Street, La Crosse, WI, 54601 USA. [2]Bowling Green State University, Bowling Green, OH 43403 USA

Previous research has demonstrated that neither total phosphorus (P) nor total nitrogen (N) is strongly correlated with primary productivity in prairie saline lakes. While iron (Fe) concentrations are high in some of these lakes, earlier studies suggest that this Fe may not be bioavailable, leading to Fe limitation of phytoplankton. To assess Fe limitation patterns, we sampled a suite of 25 saline lakes in the Northern Great Plains of North America in the early and late summer of 2004. Phytoplankton productivity and species composition were measured along with total and dissolved N, P, and Fe. The presence of the protein flavodoxin was also measured in phytoplankton cells using an immunoassay technique. Flavodoxin is an indicator of iron stress, as it is substituted for ferredoxin under Fe-depleted conditions. We found that, even in lakes with high dissolved Fe concentrations, flavodoxin expression was detected, indicating that iron limitation may play a role in regulating phytoplankton production in certain saline lakes.

LIFE IN A BURROW ON A SALT LAKE

Hudson P.J.

48 Thorne Crescent, Mitchell Park, Adelaide, South Australia 5043

Dry salt lakes are commonly perceived as being particularly harsh environments for terrestrial fauna as they are highly saline, devoid of vegetation, and are subjected to flooding, high levels of insolation, and temperature extremes. Burrows are critical to the survival of the terrestrial fauna living in these environments.

Spiders in the family Lycosidae are the largest of the salt lake invertebrates, with several species of *Tetralycosa* and one species of *Lycosa* known from salt lakes. The distinctive burrows these spiders excavate in the muddy surface can be greater than 20 cm in depth. They are offset in profile and usually of a depth such that there is a little free water in the bottom. The entrance of the burrow is sealed at various times throughout the year with a sheet of silk or a more substantial mud plug. In the latter part of summer the mud plug is usually extended by back-filling the upper section of the burrow with mud acquired during the process of excavating a new burrow from within the old one but orientated in the opposite direction. Burrow construction of this type has not been reported before for wolf spiders.

This study was done on Lake Gilles and ‘Sinclair Gap Lake’ in South Australia. Each lake has a different species of *Tetralycosa* living on it. The poster documents the temperature regime experienced on those lakes, and the morphology, orientation, and gas composition of the burrows of the spiders living there. The importance of the burrow during flooding and periods of high wasp activity is also discussed.

DISTRIBUTION OF PROTOZOOPLANKTON IN THE CHEMOCLINE ZONE OF SALINE MEROMICTIC LAKE SHUNET, RUSSIA

Khromechek E.B., Barkhatov Yu.V., Rogozin D.Yu., Goryaeva O.G., Degermendzhy A.G.

Institute of Biophysics SB RAS, Akademgorodok, Krasnoyarsk, 660036 Russia (E-mail: khrom@ibp.ru)

The main features of Shunet, a small saline meromictic lake (Russia), are high sulfur content of the bottom water layer, a pronounced chemocline, and abundance of purple and green sulfur bacteria. In 2003-04, hydrological monitoring of the lake was conducted to investigate micro- and nano-zooplankton community of the chemocline and the water column. Samples were collected in the center of the lake from the chemocline zone using a multi-syringe thin-layer sampler (Rogozin, 2002). The samples were examined to determine the species composition, concentration, and biomass of aquatic organisms. The samples contained 6 abundant species of free-living ciliates of the genera *Cyclidium, Euplotes, Holophrya, Prorodon, Strombidium,* and *Oxytricha* and a large population of phytoflagellates of the genus *Cryptomonas*, which was mainly represented by *Cryptomonas salina* in the summer time and in winter – by*Cryptomonas salina* and *Cryptomonas sp.*, the latter being more abundant.

The detected species had different habitats. The ciliates of *Oxitricha sp*. were only found in the 5 – 10 cm anaerobic chemocline layer with purple bacteria and hydrogen sulfide. The other ciliate species occurred through the water column, but their biomass was mainly concentrated near the chemocline. The peak in the vertical distribution of ciliates in the water column was registered in the 30-35 cm layer of the chemocline zone, which included a layer of purple bacteria and contained 0 to 5 mg L^{-1} hydrogen sulfide and no oxygen. Throughout the observation time, the peak of *Cryptomonas* abundance and biomass was found in the 20 cm layer near the chemocline, in the zone of abundance of purple bacteria and high nutrient, e.g. nitrogen, content. The largest abundance and biomass was observed in summer (191.01 10^6 cell L^{-1} and 12.61 mg C L^{-1} in August 2003 and 157.44 10^6 cell L^{-1} and 10.39 mg C L^{-1} in August 2004)

Cryptomonas population performed diurnal migrations over small amplitudes, descending into the purple bacteria layer in the light and going up in the dark. Water samples collected from different layers of the chemocline zone were maintained in situ for 24 h, and positive growth rate of *Cryptomonas* was only registered in the chemocline layer with purple bacteria (2.37 d^{-1} in August 2003 and 5.22 d^{-1} in August 2004). However, positive production of ciliates was observed in the layers above the chemocline, except for the ciliates of *Oxitricha sp*.)

The work was supported by grants: REC-002, Y1-B-02-04 of the U.S. Civilian Research & Development Foundation (CRDF) and RF Ministry of Education and Science, BRHE Program; Krasnoyarsk Region Science Foundation, 2N007.

SEASONAL PATTERNS AND DISTRIBUTION OF PHYTOPLANKTON IN PRAIRIE SALINE LAKES OF NORTH AMERICA

Martin C.S., Saros J.E.

University of Wisconsin – La Crosse, Biology Department, 1725 State St. La Crosse WI, 54601

Patterns of seasonal phytoplankton succession and distribution are well-defined in temperate freshwater lakes. However, patterns in prairie saline lakes have received little attention. Because these lakes are polymictic and typically fluctuate in conductivity over the summer, driving forces behind these patterns may be quite different in these lakes. We investigated phytoplankton community structure in a set of 30 lakes throughout the Great Plains of North America during early and late summer of 2004. Phytoplankton species were enumerated and cell counts converted to biovolume. In the northern Great Plains, diatoms and cyanobacteria were the dominant phytoplankton across all lakes. Most of these lakes were dominated by diatoms in spring, and by filamentous cyanobacteria in late summer. However, many bicarbonate-rich lakes deviated from this pattern, as spring assemblages were dominated by coccoid cyanobacteria, followed by late-summer diatom blooms. In the central Great Plains, diatoms, cyanobacteria and chlorophytes dominated early summer sampling, whereas cyanobacteria primarily dominated these lakes in late summer. The factors driving these patterns in this set of lakes will be discussed.

THE EFFECT OF DIETARY MANIPULATION OF POTASSIUM LEVELS ON GROWTH SURVIVAL AND WHOLE BODY CHARACTERISTICS OF JUVENILE SNAPPER, *PAGRUS AURATUS* (BLOCH & SCHNEIDER, 1801) CULTURED IN INLAND SALINE WATER FROM WESTERN AUSTRALIA.

Mc Neil J. [1], Tsvetnenko E.[1]

[1]Muresk Institute, Curtin University of Technology, 1 Turner Avenue, Bentley, WA 6102 Australia, email: jane.mcneil@student.curtin.edu.au

Inland saline aquaculture is a recent area of great interest and research. Previous work conducted with various marine species show that addition of potassium to culture water greatly improves survival, growth and ingestion rates of fish in inland saline water. Addition of supplemental potassium to diets rather than culture water has been suggested as an area for further research.

This study tested the short-term (11 days) survival and growth of pink snapper (*Pagrus auratus*) fed four purified diets containing graded levels of supplemental potassium (0, 0.2, 0.5 and 1.05% K^+) in the form of potassium chloride in saline groundwater from inland Western Australia. The control treatment consisted of fish held in ocean water and fed experimental diet without K^+ addition.

The first trial showed that snapper (mean weight 69g) did not commence feeding in the after transfer from ocean water (35 ppt) to inland saline water (35 ppt), while fish in the control group consumed an average of 1.5-2% of their biomass per day and displayed normal feeding behaviour. Fish in inland saline water began to lose equilibrium and buoyancy within three days and mortalities commenced at this time. The trial was terminated after 11 days.

The survival of juvenile snapper fed diets containing 0, 0.2, 0.5 and 1% of K^+ was 53, 73, 60 and 73%, respectively. The survival in the ocean water was 100% during the trial period and biomass increased by 8.03 g.

A second trial will test the dietary requirement of K^+ for juvenile snapper when cultured in inland saline water fortified with 60% of the K^+ level as in ocean water. This trial is necessary in order to improve the survival and ingestion rates of juvenile snapper when cultured in inland saline water. This will allow evaluation of dietary K^+ requirement of juveniles cultured in inland saline water using linear regression analysis of the dietary K^+ level versus whole body K^+ balance value. The effect of rearing environment and dietary K^+ supplementation on flesh characteristics (moisture, ash and whole body K^+) will also be assessed.

MOLECULAR ANALYSIS OF THE BACTERIAL COMMUNITY OF THE EGYPTIAN SODA LAKES OF THE WADI AN NATRUN.

Mesbah N.M.[1], Abou-El-Ela S.H.[2], Wiegel J.[1]

[1]Departement of Microbiology, University of Georgia, Athens, Ga, USA. [2]Faculty of Pharmacy, Suez Canal University, Ismailia, Egypt.

Soda lakes are the most stable naturally occurring hypersaline environments on earth, where pH values greater than 10 are common. Soda lakes are characterized by large amounts of sodium carbonate. Other salts, particularly sodium chloride also concentrate leading to the formation of alkaline, hypersaline lakes.

The Wadi An Natrun is an elongated depression located in Egypt 90 km northwest of Cairo. The bottom of the valley is about 23 m below sea level and below the river Nile The Wadi An Natrun consists of six large,

alkaline hypersaline lakes and a number of ephemeral pools. The pH of the lakes ranges from 9-11 and the NaCl concentration approaches saturation. Previous studies have shown the lakes to be habitat to dense communities of haloalkaliphilic microorganisms; however, there have not been any studies on the complete microbial diversity of these lakes. We have extracted whole community DNA from water and sediment samples from three of the large lakes of the Wadi An Natrun. The 16S rRNA gene was amplified with universal bacterial and archaeal primers, cloned and sequenced. Analysis of the sequence data showed that most of the 1021 bacterial clones analyzed fell into 6 major lineages of the domain *Bacteria*: Low G+C Gram-positive microorganisms (34%) and *Proteobacteria Cytophaga-Flexibacter-Bacteroides* (13%) and *Actinobacteria* (2%). The remaining 15% were assigned to the *Verrcuomicrobiales, Cyanobacteria, Spirochaetales, Chloroflexaceae* and candidate divisions. Only 20% of the cloned sequences had identities $\geq$ 95% with cultivated microorganisms isolate from other alkaline, hypersaline environments such as *Rhodobaca bogoriensis, Thiorhodovibrio sibirica, Tindallia magadii* and *Spirochaeta africana.* Comparisons of all the obtained clone libraries (each with 300 clones) show that the bacterial communities are significantly different, despite the fact that they are all fed from water originating from the river Nile.

LIFE AT EXTREME LIMITS: HALOPHILIC ALKALITHERMOPHILES, A NOVEL GROUP OF EXTREMOPHILES.

Mesbah N.M., Maurizio P., Wiegel J.

Department of Microbiology, The University of Georgia, Athens, GA 30602-2605.

The halophilic alkalithermophiles (haloalkalithermophiles) are a special physiological group only adapted to grow at three extreme environmental conditions, high temperature, pH and salt concentration, representing an ecological as well as an evolutionarily interesting combination. While previous studies have led to the isolation of haloalkaliphiles (Feng et al., 2005, Zhang et al., 2005) and alkalithermophiles (Engle et al. 1996, Olsson et al., 2003), '*Bacillus thermoalcalophilus*' and *Halonatronum saccharophilum* are the only aerobic haloalkalithermophiles isolated as of now (Sarkar, 1991, Zhilina et al., 2001) . No anaerobic haloalkalithermophiles or archaeal haloalkalithermophiles have been isolated thus far. The scarcity of such isolates reflects the lack of exploration of this novel group

We will present the isolation of three novel halophilic alkalithermophilic microorganisms from the Wadi An Natrun and from salt flats located in the Buffalo Springs area, Nevada. The isolates are in the Low G + C Gram positive group (*Bacillus/Clostridium*). All isolates have a large NaCl range (1-3M, 0-3M and 1-2.5M respectively) and tolerate higher NaCl concentrations than their closest relatives. They are all obligate thermophiles, not growing at temperatures below 42^{o}C ($Temp_{opt}$ 68, 64 and 60 ^{o}C respectively) and alkaliphilic (pH_{opt} 9.4, 9.2 and 9.0 measured at 60^{o}C). Doubling times for all isolates are long, ranging from 10 to 48 hours, and substrate utilization spectra are narrow in comparison with their closest relatives.

The haloalkalithermophiles are a unique group that has been only recently recognized. They are expected to possess unique adaptive mechanisms such as novel transport mechanisms, osmoregulatory compounds or enzymes. In addition, the search for halophilic alkalithermophiles will be an important scientific inquiry that will enlarge our knowledge of the "unseen majority" (Whitman et al., 1998) of microorganisms and will extend biodiversity beyond the presently described physiochemical boundaries for microbial growth.

ALGAL STRATEGIES AND THEIR DISTRIBUTION ACCORDING TO THEIR SALINE GRADIENTS AT THE COASTAL LAGOONS FROM PUERTO VIEJO, LIMA, PERU.

Montoya H.T.

National History Museum, Biological Sciences Faculty. Universidad Nacional Mayor de San Marcos

The central coastal plain of Peruvian land has peculiar wetlands with lagoons which appear as oases in the vast desert. The evaluated superficial lagoons of Puerto Viejo located at Cañete province with San Antonio and Chilca districts, are surrounded by sandy lomas. They are between 12º 33' 14,96" - 12º 34' 48,05"S and 76º 42' 50,49" - 76º 41' 53,37"W. Standard algal collection with the physical - chemical parameters (pH, salinity, temperature, phosphate $P0_4^-$, nitrate $N0_3^-$) of the aquatic ecosystems were registered irregularly between 1993-2003.

Lagoon ecosystem has different habitats (freshwater, brackish, saline) where the aquatic salinity gradients were between 0 - 90 ppt to saturated (NaCl), pH range were 6.5 – 10.5, phosphate up to 50 mg/L and nitrate up to 0.88 mg/L. They were related to the fluctuating hydric regime during the flooding and desiccation periods where halophilic microalgae thrive in the hypersaline environments forming part of saline crusts.

Algal phenotypic plasticity and the heterogeneity of algal groups were related to their adaptative strategies. Then, the species *Tetraselmis contorta, Prorocentrum Exuviaella cassubica,* and *Aphanizomenon flos-aquae*, have evolved an alternation of generations, between vegetative plancktonic and resting benthic phases (akinetes, spores) of the life cycle. This combination offers them one viable life strategy for successful colonization. Therefore, resting stages can serve as refuge populations for algal recolonization following periods of unfavorable environmental conditions.

The phytoflagelletes are 22.6% of the algae flora. The indicator species such as the heterocystous nitrogen fixers represented the 21.6% of the cyanophyte populations. Besides, algal distribution according to the tolerance to salinity range showed that 70.7% of the species were oligo-euryhaline (0-10 ppt) and oligo-meso-euryhalines (0-30 ppt) with 34 and 41 indicator species respectively. The highest tolerant species were *Dunaliella viridis* (polystenohaline >30 ppt) and the meso-polyeurihaline (1- >30 ppt) were typified by *Spirulina subsalsa, Lyngbya aestuarii* and *Dunaliella salina.*

The species algal growth with diverse communities on coastal lagoons ecosystems from Puerto Viejo illustrated their diversity, complexity and reproductive strategies under their unstable and saline environmental conditions.

THE EFFECT OF SUDDEN CHANGE IN IONIC CONCENTRATION ON WESTERN KING PRAWN *PENAEUS LATISULCATUS* SURVIVAL, OSMOREGULATORY CAPACITY AND CONDITION IN INLAND SALINE WATER

Prangnell D.I., Fotedar R.

Muresk Institute, Curtin University of Technology, 1 Turner Ave, Bentley WA 6102 Australia. email: david.prangnell@student.curtin.edu.au

Western king prawns (*Penaeus latisulcatus*) are a candidate species for culture in inland saline water, which is often deficient in potassium (K^+). Inland saline water requires K^+ fortification to allow prawn survival and growth. Past research has shown that prawns can tolerate rapid change in salinity but no research has yet been done on change in individual ions, such as K^+. The aim of this study was to determine the effect of rapid change in K^+ concentration in inland saline water on western king prawn survival, osmolality and condition indices.

A 19-day trial was conducted in twelve 125L closed systems. Nine prawns per tank (5.32 ± 0.12g) were acclimated to inland saline water from Wannamal WA (31°15”S, 116°05”E) at 32ppt. After three days prawns were subject to increase in medium K^+ concentration over one hour using dissolved potassium chloride, four tanks to 100% of the marine water K^+ concentration (IS100) and four tanks to 80% of the marine water K^+ concentration (IS80). Identical inland saline water was added to four tanks over the same time period as a control (ISW). Survival and ingestion rate were then recorded over 19 days. Prawns from each tank were measured (length and weight), had haemolymph withdrawn for determining serum osmolality and were analysed for condition indices pre- and ten minutes post-ionic change, and after 19 days.

At the conclusion of the trial survival was 71% in IS80 and 78% in IS100. 100% mortality was observed in ISW by day 11. There was no significant difference ($P>0.05$) in acute (96 hour) survival between water types. Chronic (364 hour) survival and ingestion rate were significantly higher ($P<0.05$) in IS100 and IS80 than in ISW. Osmoregulatory capacity (OC) was significantly lower ($P<0.05$) post- than pre-change and significantly higher ($P<0.05$) than both pre- and post-change at the conclusion of the trial in both IS100 and IS80. There was no significant difference ($P>0.05$) in OC between water types at any time period. Wet and dry hepatopancreas and tail muscle indices were significantly lower ($P<0.05$) at the conclusion of the trial than both pre and post-change in IS100 and IS80. Hepatopancreas and tail moisture content increased significantly ($P<0.05$) in each water type over time. These results indicate that prawns can tolerate an increase in K^+ content in inland saline water and that the higher K^+ concentration increases OC. However after 19 days prawn hepatopancreas and tail muscle energy reserves (nutrients) were significantly lower, indicating prawns were still living under stressed conditions.

POPULATIONS OF PHOTOTROPHIC BACTERIA AND THEIR ACTIVITIES IN THE CHEMOCLINES OF MEROMICTIC LAKES SHUNET AND SHIRA (RUSSIA, SIBERIA)

Rogozin D.Yu.[1], Chan’kovskaya Yu.V.[2], Muratova Yu.S.[2], Yefremova V.S.[2], Yarosh E.V.[2], Rybin A.A.[2], Degermendzhy N.N.[3]

[1]Institute of Biophysics, Siberian Division, Russian Academy of Sciences, Krasnoyarsk, Russia; [2]Krasnoyarsk State University, Krasnoyarsk, Russia; [3]Krasnoyarsk State Medicine Academy, Krasnoyarsk, Russia.

Meromictic lakes are suitable model systems for research on aquatic microbial communities because a number of different physiological groups of microorganisms substitute each other along the vertical gradient of light, oxygen and sulfide (Jorgensen et al, 1979, Guerrero et al, 1985, Montesinos et al, 1983, Overmann et al, 1991). The chemocline of meromictic lakes is of special interest because of distinctly heterogeneous vertical distribution of bacterioplankton, phytoplankton and protozooplankton. Many biological and biochemical processes such as photosynthetic and chemosynthetic rates, sulfate- and sulfur-reduction rates, vertical migration and feeding rates of zooplankton, are markedly influenced by planktonic “layering” (Jorgensen et al, 1979; Baker et al, 1985; Overmann, 1997).

We used the hydraulic multi-syringe thin-layer sampler (Rogozin et al., 2005) to study the spatio-temporal heterogeneity of microbial and physico-chemical characteristics in the chemoclines of steppe Shira Lake and Shunet Lake (Siberia, Russia) in 2002 – 2005. Both lakes are meromictic, but in Shunet Lake the gradients of salinity, redox potential and sulfide in the chemocline are much more steep than in Shira. The purple sulfur bacteria (PSB) dominated the upper layer of redox zone (oxic-anoxic interface) of chemoclines in both lakes. According to morphology and absorption spectra these bacteria were identified as *Lamprocystis purpurea* (Chromatiaceae). In both lakes the maximal development of PSB was observed in late summer. In summer the abundance of PSB in Shunet was as high as 1.5×10^8 cells ml^{-1} and was visible as distinct “purple layer” of 5 cm thick. High biomass of PSB and activities of anoxigenic photosynthesis and sulfate-reduction registered at the depth of “purple” layer give an evidence of ecological significance of PSB for Shunet Lake ecosystem. In both lakes the populations of green sulfur bacteria Chlorobiaceae developed under PSB layers.

Until the present study it was generally believed that Mahoney Lake (Canada) is characterized by highest abundance of PSB in the chemocline and high ecological significance of PSB (Overmann 1997). Evidently, Shunet Lake is analogous to Mahoney Lake in these respects.

In Shira Lake the PSB abundance in summer was about 10^6 cells ml^{-1}, which is usual for meromictic lakes. Relative contribution of PSB into carbon turnover of Shira Lake was much less than of Shunet Lake. Currently the structure of bacterial community of the chemocline of Shunet Lake is under study by PCR and DGGE of 16sRNA gene fragments and by FISH methods.

This work was partly supported by Russian Foundation for Basic Research (grants № 05-04-48784 and 05-04-97708), Krasnoyarsk Foundation for Science (grant 05-04-97708), program of Russian Academy of Sciences «Origin and Evolution of Biosphere» (contract № 10002-251/П-25/155-320/200404-074), CRDF (award No.KY-002-X1) and joint program of Russian Ministry of Education and CRDF (individual grant for D.Yu. Rogozin Y1-B-02-06).

THE IMPORTANCE OF PHYSIOLOGICAL PARAMETERS IN REGULATING ALGAL POPULATIONS IN THE SWAN RIVER ESTUARY, WESTERN AUSTRALIA

Rosser S.M.J

Department of Environmental Biology, Curtin University of Technology, GPO Box U1987, Perth, WA, 6845

Nutrient uptake physiology was more important than most physico-chemical parameters studied in determining phytoplankton species composition and distribution at a single site in a mesotrophic – eutrophic seasonal estuary, the Swan River, Western Australia. Phytoplankton succession and abundance in estuaries is known to be influenced by the relative strengths of various seasonally changing physical and chemical factors. Previous studies of Swan River Estuary phytoplankton biomass and composition have identified salinity, temperature, rainfall and nutrients as the most important controlling factors. These conclusions are generally based on analysis of data from river length transects and depth integrated day-time sampling. They describe influences affecting whole system phytoplankton abundance and succession. Many of the typical seasonal blooms that develop are ephemeral and only extend over relatively small areas.

Uptake rates for nitrate (r^2 0.501) and urea (r^2 0.512), along with temperature (r^2 0.605) were shown to have the greatest influence on phytoplankton distribution over depth and time. Of next most importance were O_2 saturation (r^2 0.638), orthoP (r^2 0.575) and NH_4^+ (r^2 0.515) concentrations. Salinity, while having been demonstrated as a master factor in phytoplankton species composition and distribution over the length of the Swan River, was not significant (r^2 0.056, n=46) on the local scale at which ephemeral blooms develop.

This research highlights the need for knowledge of nutrient flux rates within a system to adequately understand or predict the systems' potential for support of phytoplankton growth.

SALINITY - A KEY FACTOR DETERMINING TEMPORAL DISTRIBUTION PATTERNS OF PERIPHYTIC DIATOMS IN THE CANNING RIVER, WESTERN AUSTRALIA

Sadlo B., John J.

Curtin University of Technology, Perth, Western Australia

The temporal distribution patterns of periphytic diatoms in the Upper Canning River at Kent Street Weir were investigated in 2004 to establish the relationship between water quality and community structure. Diatom taxa have well defined ecological optima and tolerances, responding rapidly to changes in water chemistry. The variables of pH, temperature, dissolved oxygen, conductivity, salinity and turbidity were measured against site locations using multivariate analysis (stress: 0.01). Ten of thirteen diatom families were represented in the samples, with 94 species identified from 38 genera. Temperature appeared to be the determining factor explaining variation in diatom assemblages between sites, however it cannot be discounted that a combination of variables may have influenced temporal distribution patterns and hence variation in diatom community structure. Shifts in species composition within diatom communities were found to be closely associated with seasonality and changing estuarine hydrology. During autumn there was a distinct difference between diatom community structure above and below the weir. In winter however, diatom communities were more closely related in terms of species composition. Results indicate that temporal distribution patterns of periphytic diatom assemblages such as salinity and temperature, are influenced by the ecological preferences of individual species and environmental factors such as salinity an d temperature

MODELING PRIMARY PRODUCTION PATTERNS IN PRAIRIE SALINE LAKES OF THE GREAT PLAINS, USA

Salm C.R.[1], Saros J.E.[1], Osburn C.L.[2], Fritz S.C.[3]

[1]University of Wisconsin-La Crosse, 1725 State Street, La Crosse, WI, 54601 USA [2]US Naval Research Laboratory, 4555 Overlook Ave SW, Washington DC 20375 USA [3]University of Nebraska-Lincoln, Department of Geosciences, Lincoln, NE 68588 USA

While rates of primary productivity are often linked to total phosphorus concentrations in freshwater lakes, no pattern has yet been found for saline lakes. Most studies of phytoplankton production in saline lakes of the Great Plains of North America have used chlorophyll *a* as the indicator of productivity levels. However, chlorophyll *a* may not be an accurate measure of primary production in these systems, due to potential grazing by large zooplankton populations. In addition, while total nutrient concentrations are high in these lakes, the high concentration of dissolved organic material (DOM) may interfere with primary productivity by binding with nutrients and making them unavailable to phytoplankton.

To explore patterns of primary production in saline lakes, we measured rates of primary production with the ^{14}C method in 25 lakes in the Northern and Central Great Plains during both early and late summer. Over 20 parameters were measured for each lake, including particulate and dissolved nutrients, conductivity, ion concentrations, temperature, pH, light attenuation and DOM characteristics. Stepwise regression was applied to the dataset to identify key parameters for the development of production models. Our results indicate that patterns varied from early to late summer, with higher rates of primary production occurring in late summer and the main limiting factors changing from nitrate to total phosphorus. Other significant variables included calcium, DOC, alkaline phosphatase activity, and alkalinity. Further statistical methods are being explored to improve correlation and develop an accurate model for primary productivity in these saline lakes.

TRANSITION FROM PLANKTONIC TO BENTHIC ALGAL DOMINANCE ALONG A SALINITY GRADIENT IN THE SHARK BAY SALT SOLAR PONDS, WESTERN AUSTRALIA

Segal R.D.[1], Waite A.M.[1], Hamilton D. P[2]

[1]Centre for Water Research, University of Western Australia, Perth, Western Australia. [2]Centre for Biodiversity and Ecology Research, University of Waikato, Hamilton, New Zealand.

Highly regulated salinity gradients in solar salt pond concentrating sequences provide an opportunity to investigate *in situ* salinity impacts on aquatic flora and fauna. The Shark Bay Salt solar ponds at Useless Inlet in Western Australia vary in salinity from seawater to four times seawater over the pond sequence. We observed a shift from planktonic to benthic primary productivity as salinity increased. Water column photosynthesis and biomass decreased markedly with increasing salinity, while benthic productivity increased as cyanobacterial mats developed. Correspondingly, productivity shifted from autotrophy to heterotrophy in the water column and from heterotrophy to autotrophy in the benthos. Both shifts occurred at intermediate salinity ($S = 110$ g kg^{-1}, $\rho = 1.087$ g cm^{-3}) in the pond sequence, where there was little production by either. Within individual ponds, productivity, algal biomass and physico-chemical conditions were relatively constant over one year, with only water column photosynthesis significantly different between seasons, mostly due to greater winter production. Transitions between benthic and planktonic production and their relative magnitudes appear to be driven mostly by direct responses to salinity stress, but also by changes in nutrient availability and grazing, which are also influenced by salinity.

DIATOMS IN ACIDIC SALINE LAKES IN WESTERN AUSTRALIA: WHAT DO THEY INDICATE?

Thomas E., Taukulis F., John, J.

Department of Environmental Biology, Curtin University of Technology, GPO Box U1987 Perth WA 6845

Salinisation and acidification are two major resource management issues facing inland waterbodies in Western Australia. Secondary salinity has been steadily increasing in many lakes since European settlement, with wetlands in the wheatbelt region the most severely affected. Additionally, many of the saline lakes are acidic.

While the biota of saline lakes has been extensively studied, very little work has been done on the organisms inhabiting waterbodies that are affected by both salinity and acidity. An understanding of the principal factor that governs the biodiversity in these systems is lacking. Diatoms are acknowledged to be sensitive indicators of both salinity and acidity, however limited research is available on the combined impact of both. The objectives of this study were to investigate the distribution of diatoms in acidic saline lakes and to identify characteristic diatom assemblages.

The study sampled 18 lakes from the south-west of Western Australia. Salinity ranged from 23.7 g/L to 156.8 g/L. Seven of these lakes were acidic with pH readings of < 6.6 whilst the remaining wetlands were alkaline (pH > 7.5). A total of 48 species were identified from the lakes and of those 20 were found to be unique to the acidic and saline sites. Multivariate analysis was used to determine the relationship between diatoms and the physico-chemical parameters measured. Although both pH and salinity influenced diatom distribution, pH was identified as the major determinant of community structure.

ZOOPLANKTON OF LAKE SHUNET (RUSSIA, KHAKASIA): VERTICAL STRUCTURE AND TROPHIC RELATIONSHIP WITH HEMOCLINE MICROBIAL COMMUNITY.

Tolomeev A.P., Degermendzhy A.G.

Institute of Biophysics SB RUS, Akademgorodok, Krasnoyarsk, 660036 Russia (E-mail: tolomeev@ibp.ru)

Seasonal dynamics of the vertical structure of zooplankton and its trophic relationship with hemocline microbial community were studied in salt meromictic lake Shunet (54'25' N, 90'14' E) during 2003-2004. The lake's depth is 6.2m and an open water area of 0.47km^2. The salinity increases with the depth from 14 mg L^{-1} to 66 mg L^{-1}. Calanoid copepod *Arctodiaptomus salinus* is the dominant species. Cladoceran of *Moina* and *Bosmina* genera were temporarily present in pelagic waters during the summer period (less then 5 ind.L^{-1}). Rotifers comprise *Brachionus plicatilis, Keratella* sp. and *Hexarthra* sp. *A.salinus* was found practically in all oxygen layers over the year. Its vertical distribution decreased with depth at the beginning of vegetation season and was close to uniform in summer time. In July *Hexarthra* sp. of high density 118 ind. L^{-1} was found in the layer of 0-3m. In August *B.plicatilis* reached a very high density of 1175 ind. L^{-1} but in the restricted layer of 5.0-5.2m. November zooplankton were represented only by *A.salinus* and *B.plicatilis*. Rotifers were found in all oxygen layers, but their maximum was still at depth 5m.

The investigations of *A.salinus* feeding on microbial community from the hemocline zone of lake Shunet were conducted in laboratory conditions using semi-flowing technique suggested by Gladyshev et al. (1999). Biomass of microorganisms in control and experimental samples were determined by direct counting method under an epifluorescent microscope. Microbial community comprised four genera of ciliates (*Cyclidium, Prorodon, Oxitricha, Strombidium*), cryptomonads *Cryptomonas salina*, heterotrophic nanoflagellates and an abundant population of purple bacteria. It was shown that *A.salinus* consumed all components except heterotrophic nanoflagellates. Purple bacteria were the main part of the ration, 0.044 mg ind.$^{-1}$ L^{-1}. The total ration amounted to 0.58 mg ind.$^{-1}$ L^{-1} (120% of body weight).

Despite *A.salinus* was able to consume the majority of hemoclin microorganisms in laboratory conditions, the animals could not feed on them directly in the lake. Their vertical distribution was limited to the depth 5.0m, whereas the hemocline zone began 20cm deeper. The reason why *A.salinus* was not able to reach the boundary of the hemocline zone can be explained by the presence of the layer of cyanobacteria *Synechocystis* sp. just above hemocline. A short time laboratory experiment showed that water of this layer appears to be toxic for *A.salinus* (animals die in 4 hours) but not for *B.plicatilis*.

The work was supported by grants: REC-002, Y1-B-02-04 of the U.S. Civilian Research & Development Foundation (CRDF) and RF Ministry of Education and Science, BRHE Program; Krasnoyarsk Region Science Foundation, 2N007.

STUDIES ON DESULPHATATION OF BRINE/BITTERN FOR PRODUCTION OF PURE SALT AND MARINE CHEMICALS IN INDIA

Vohra R.N., Dave R.H., Gandhi M.R., Mohandas V.P., Joshi H.L., Langalia J., Daga S.L., Ghosh P.K.

Salt & Marine Chemicals Discipline, Central Salt and Marine Chemicals Research Institute, Bhavnagar - 364002, Gujarat, India

Sea and sub-soil brines can be utilized for the production of salt and marine chemicals. In view of sulphate impurities in the brine, the salt tends to be more contaminated with gypsum and recovery of potash in the form of KCl is problematic. Desulphatation of bittern has been shown to yield a composition suitable for carnallite ($KCl.MgCl_2.6H_2O$) production, from which KCl can be recovered following the conventional processes of decomposition and hot leaching. However, desulphatation is a costly proposition unless there are multiple gains to be realized and there is access to inexpensive sources of $CaCl_2$. The presentation will describe our invention of brine desulphatation prior to salt formation for production of pure salt of a quality not realized

previously in the field. The mother liquor bittern is used for recovery of carnallite. It is shown further that when carnallite is decomposed, the resultant carnallite decomposed liquor rich in $MgCl_2$ is an ideal source of pure $Mg(OH)_2$ and $CaCl_2$. The former can be converted into refractory grade MgO while the latter can be employed for desulphatation thereby realizing an integrated process, with brine and lime as the only raw materials required. It is further shown that the aqueous $CaCl_2$ helps recycle Br^- and KCl lost in the course of carnallite formation and decomposition, respectively. This approach has helped us to achieve high yields of both KCl and Br^-; moreover, in the case of the latter, its concentration in end bittern can be raised to ca. 8.4 g/L with >90% bromide recovery in bittern, compared to the normal 3-4 g/L bromide concentrations employed in India presently. In a variation of the theme, sea bittern can be concentrated to recover kainite ($KCl.MgSO_4.2.75H_2O$) mixed salt, which can be transformed into pure schoenite ($K_2SO_4.MgSO_4.6H_2O$). The schoenite end liquor can be desulphated by a similar approach to that mentioned above and the desulphated liquor is shown to be a value source of KCl. The latter can be utilized along with the schoenite to produce K_2SO_4 in integrated manner, with requirements of bitten and lime only. The inventions summarized above are covered by recently granted U.S. patents and patent applications.

THE AQUATIC INVERTEBRATES FROM A THREE SPRINGS CLAYPAN, WESTERN AUSTRALIAN WHEATBELT.

Ward M.J.[1], Campagna V.S. [1], Arthur P. [2]

[1]Outback Ecology Services, Perth, Western Australia. [2]Luzenac Three Springs, Western Australia.

Luzenac Australia Pty Ltd, a subsidiary of Rio Tinto, own and operate the Three Springs Talc Mine, which is the largest white talc producer in Australia. The mine, located in the mid west region of Western Australia, has been operating since 1961 and has been releasing hypersaline mine water (dewatering) to a local claypan for at least 20 years.

Dewatering has caused permanent inundation of a once temporary claypan. Rich Consulting Services and Outback Ecology Services have been surveying the water and sediment quality, fringing flora, microalgae and avian fauna since 2000. The aims of the surveys are to develop an understanding of the ecosystem that has developed, and determine the potential impacts the dewatering discharge may have to this 'created' ecosystem. This poster describes the aquatic invertebrates of the ecosystem.

LAKE WAY: PRELIMINARY STUDY OF THE AQUATIC ECOLOGY AND POSSIBLE EFFECTS FROM MINING OPERATIONS.

Ward, M. J[1], Gregory, S. J. [1], Campagna, V. S[1]., Marshall, L.[2], Bond, K.[3]

[1]Outback Ecology Services, Perth, Western Australia. [2]Agincourt Operations, Wiluna, Western Australia. [3] Kewan Bond Pty Ltd, Fremantle, Western Australia.

Lake Way is a large temporary salt lake, approximately 270 km^2, and is located at the top of the Salt Lake Division, a system of salt lakes that form part of an ancient palaeodrainage system. The lake is located in the "Wiluna" land system within the Carnegie Botanical District. This district is characterised by gently undulating plains covered with mulga (*Acacia aneura*) and shrub steppe (*Hakea, Acacia* and *Triodia basedowii*) covering the sandy area (Beard 1990) with extensive salt lake systems supporting large halophyte communities

(Agincourt 2004).

The Agincourt Wiluna Gold Mine is located approximately 5km south of Wiluna. The mine operates near and discharges to Lake Way, which is approximately 17 km south east of Wiluna. Agincourt engaged Outback Ecology Services (OES) to survey the sediment and water quality, as well as the microalgal and aquatic invertebrate communities and fringing flora at Lake Way in early 2004, in the form of a baseline survey.

In 2005, additional hypersaline water was released onto Lake Way raising environmental concerns from stakeholders. These concerns are being addressed by a new monitoring program during the life of the mine and beyond.

EXPERIMENTAL STUDY OF 25˚C AND 40˚C ISOTHERMAL EVAPORATION OF BRINES FROM DAMXUNG CO SALT LAKE, TIBET, CHINA

Yuan, H.R., Zheng M.P., Si, D.X.

R & D Center for Saline Lake and Epithermal Deposit, Chinese Academy of Geological Sciences, Beijing 100037, China

Damxung Co Salt Lake, Tibet, is a surface brine lake located in the interior of the Tibetan Plateau, at 86º45′ E and 31º35′ N, covering an area of 55 km^2. The lake level is 4475 m a.s.l. and the water depth ranges from several meters to 18 m. According to the chemical analysis and mineral assemblages, the lake is hydrochemically of carbonate type. Evaporation experiments were conducted separately on brines of two different salinities: (1) brine with a salinity of 26%, a specific gravity of 1.214 and pH=9.34, evaporated at a constant temperature of 25˚C; and (2) brine with a salinity of 36%, a specific gravity of 1.270 and pH=9.34, evaporated for 8, 26, 48, 72 and 95 hours separately at a constant temperature of 40˚C. According to the results of these experiments, the following four assemblages of saline minerals are distinguished: (1) halite+thermonatrite+trona (minor), (2) halite+trona+thermonatrite (minor)+glaserite (rare), (3) halite+trona+lithium carbonate (minor)+ glaserite, and (4) halite+trona+lithium carbonate (abundant)+glaserite+sylvite (minor).

The experiments show that: with continuous evaporation and concentration of salt lake brines, NaCl is saturated in water and CO_3^{2-} is also relatively concentrated, and halite, thermonatrite and trona are first precipitated. With intensifying evaporation, the concentrations of alkaline minerals increase and thermonatrite is gradually transformed into trona, and in addition, there also appears minor glaserite. Afterwards, with continuous prolongation of the evaporation, the brines are more highly concentrated and the precipitation of lithium carbonate varies from minor to abundant and again to minor. Moreover, the crystal shape and mode of occurrence of lithium carbonate also change somewhat, i.e.: knife-edged, prismatic crystals of lithium carbonate that are fine and very fine (0.01–0.05 mm) in size and mainly occur in halite crystals apparently increase in size and become coarse prismatic ones with a maximum length of 15–2.0 mm after 48 hours of evaporation. Then lithium carbonate is mainly precipitated separately and closely associated with halite and trona and its concentration also increases progressively. After 95 hours of evaporation, the concentration of lithium carbonate decreases relatively. Because of increasing concentration of potassium in brines and presence of SO_4^{2-} ions in brines, the brines are saturated progressively, thus resulting in precipitation of more or less glaserite in the middle and late stages of evaporation. The concentration of glaserite may reach a maximum of 10%. In addition, small amount of sylvite is also precipitated. When salt lake brines evaporate and are concentrated to those with a salinity of 38.6%, pH=10.12 and a specific gravity of 1.321, the brine evolution ends and the precipitation of minerals also goes toward the eutectic points of carbonate, potassium sulfate and chloride (halite+sylvite) and then ends.

In summary, the brine of Damxung Co Salt Lake, Tibet, is a complex water-salt system composed of Na,

K, Li, Cl, SO_4, CO_3^{2-} and $B_4O_7 \cdot H_2O$ and its mineral assemblages show the features of those of carbonate type salt lakes. The concentrations of Li and K, which are of economic value, are comparable to those in Zabuye Salt Lake that is being exploited; whereas the Ca and Mg concentrations in brines are very low, which is more favorable for extraction of Li_2CO_3. In addition, the brines also have higher concentrations of K, SO_4, Rb and Br, which may be extracted as by-products. Salt gradient salt solar ponds may be used for the environmentally friendly green production of chemicals.