Intergovernmental Oceanographic Commission

Workshop Report No. 49

AGU-IOC-WMO-CPPS Chapman Conference: An international Symposium on "El Niño"

Guyaquil, Ecuador, 27-31 October 1986

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No.	Title	Publishing Body	Languages
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand 24-29 September 1973 UNDP (CCOP), 138 pp.	Office of the Project Manager UNDP/CCOP c/o ESCAP Sala Santitham Bangkok 2, Thailand	English
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (Unesco Technical Paper in Marine Sciences, No. 20).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean, Monte Carlo, 9-14 September 1974.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock)
4	Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974.	FAO Via delle Terme di Caracalla 00100 Rome, Italy	English (out of stock) Spanish (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, Kingston, Jamaica, 17-22 February 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, 1-6 September 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/Unesco/EAC, Nairobi, Kenya, 25 March-2 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters, Penang, 7-13 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience, Mauritius, 9-13 August 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring, Monaco, 14-18 June 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock) Russian
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain, Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, Fort-de-France, Martinique 28 November-2 December 1977.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area, Port of Spain, Trinidad, 16-18 January 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas, Abidjan, Ivory Coast, 2-9 May 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific, Santiago de Chile, 6-10 November 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Russian
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS), Moscow, 9-11 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
17 Suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System, Moscow, 2-6 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
18	IOC/Unesco Workshop on Syllabus for Training Marine Technicians, Miami, 22-26 May 1978 (Unesco reports in marine sciences, No. 4)	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) French Spanish (out of stock) Russian
19	IOC Workshop on Marine Science Syllabus for Secondary Schools, Llantwit Major, Wales, U.K., 5-9 June 1978 (Unesco reports in marine sciences, No. 5).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian Arabic
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources, Bandung, Indonesia, 17-21 October 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
21	Second IDOE Symposium on Turbulence in the Ocean, Liège, Belgium, 7-18 May 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
22	Third IOC/WMO Workshop on Marine Pollution Monitoring, New Delhi, 11-15 February 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Russian
24	WESTPAC Workshop on Coastal Transport of Pollutants, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
25	Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, Bermuda, 11-26 January 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (superseded by IOC Technical Series No. 22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region, Mexico City, 24 September-5 October 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Nouméa, New Caledonia, 9-15 October 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes Lima, 20 April-5 May 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
29	WESTPAC Workshop on Marine biological methodology Tokyo, 9-14 February 1981.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
30	International Workshop on Marine Pollution in the South-West Atlantic Montevideo, 10-14 November 1980.	IOC, Unesco Place de Fontenoy, 75700 Paris, France	English (out of stock) Spanish
31	Third International Workshop on Marine Geoscience Heidelberg, 19-24 July 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32	UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime Paris, 27 September - 1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish

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1. INTRODUCTION

The AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on "El Niño" brought together about 130 marine and atmospheric scientists from many developed and developing Member States and from widely varied disciplinary backgrounds, who share a common interest in the various aspects of El Niño research. The Conference was organized by the American Geophysical Union (AGU) under a grant from the National Science Foundation, who funded the US organizational costs and travel for participants from the developed nations, mostly from the USA, Europe and Australia. The Conference was co-sponsored and co-organized by the Intergovernmental Oceanographic Commission (IOC), with support of the World Meteorological Organization (WMO) and the South Pacific Permanent Commission (CPPS). These organizations financed local hosting expenses as well as travel costs for participants from developing nations, most of whom came from Latin America. An important part of these expenses was covered through preparatory assistance funds provided to IOC by the United Nations Development Programme (UNDP) for the UNDP-IOC-CPPS Regional Project on Monitoring and Prediction of the El Niño Phenomenon in the South-East Pacific: Application to Development. The Instituto Nacional de Pesca, Guayaquil, Ecuador, under the able direction of Dr. Roberto Jimenez, hosted the Conference and provided excellent facilities, including the invaluable assistance of simultaneous interpretation between Spanish and English (about half the participants spoke Spanish, the other half English).

The Session structure for the Conference (oral and poster presentation) is given in Annex I.

In their post-Conference reports to the sponsoring organizations, many of the participants remarked that one of the most valuable items provided by the Ecuadorian hosts was a large hall adjacent to the auditorium, equipped with a sufficient number of large easels to accommodate scientific poster presentations simultaneously. This made it possible to leave the posters up for the entire week, providing the participants with ample opportunities to browse through them at their convenience and resulting in many more exchanges with poster authors. On the night of the second day, about two hours were devoted to informal show-and-tell presentations by participants who had brought slides, movies and video-tapes on topics of broad interest related to El Niño. These activities contributed greatly to the success of the meeting by providing excellent opportunities for interaction between scientists from many countries, and by promoting a more relaxed atmosphere and spirit of comraderie between the participants.

2. MAIN RESULTS

One of the primary expectations of Chapman Conferences is that they give students and young scientists the opportunity to present their dissertation research to the scientific community and expose them to other scientists in their field. Twelve graduate (MSc, PhD) students from eight institutions were supported to attend the Guayaquil Chapman Conference, most of them giving their presentations orally. Perhaps half again as many had recently received their graduate degrees. More difficult to assess, however, but nonetheless significant, is the experience gained by many of the young Latin American scientists who have had few opportunities to expose their work to the international scientific community, and to benefit from the contact with other established scientists.

The disciplinary, geographical and topical scope of the conference was immense, with presentations ranging from the latest (interactive) atmospheric and oceanic numerical models, currently being used in predictive mode, to a series of excellent papers on the biological impacts of the intense 1982-83 El Niño on fish, birds and mammals. One of the outstanding success stories of the Conference is described below as an example of the benefits achieved.

At the Conference, a group of scientists from various disciplines (with little or no prior contact between them) presented evidence on El Niño episodes that preceded the use of sea thermometry in the 20th and late-19th centuries (events that occurred 500, 5 000, even 500 000 years ago). These diverse investigators coalesced (in Guayaquil) into a research group devoted to the study of El Niño in the Ancient Record (EINAR).

The formation of the EINAR group was catalysed by the presentations of seven scientists. Quinn et al. laboriously culled historical accounts of El Niño from primary sources as old as 450 years. Shen described variations, related to El Niño, of biologically mediated cadmium deposits in eastern Pacific corals, which can often provide core records of hundreds of years. Thompson used ice-core accumulation; the inferred variations in annual precipitation correlated closely with the historical El Niño activity, reported by Quinn et al.. Prospects for next proxy records of ancient El Niño events were announced by Rollins et al. who described morphological and geochemical changes in the growth of molluscan shells from the Peruvian littoral. Baumgartner pointed out the potential of organic laminated sediments in the Gulf of California for preserving a high-resolution, long-term record of El Niño activity. Carbon and archeological remains were used by Wells to date flood deposits along the Peru coast that were attributed to late Pleistocene and Holocene El Niño events. Finally, DeVries proposed that the early Pleistocene southward retreat of cold-water mollusks from north-west Peru could be accounted for by the onset of El Niño conditions.

This diversified group of scientists, who met for the first time in Guayaquil, have continued their fruitful exchange of ideas through a newsletter called the ELNAR Circular. Through the Circular, the participation has increased seven-fold since the Guayaquil Conference, with the addition of micro-palaeontologists, dendrochronologists and climatologists.

3. CONCLUSIONS

The AGU-IOC-WMO-CPPS Chapman Conference on El Niño will leave a rich legacy to the scientific community. At the time of going to press, at least 30 manuscripts by the Guayaquil participants have been received by Dr. J.J. O'Brien, the editor of the Journal of Geophysical Research (JGR-Oceans). Following the refereed reviews of the manuscripts, many of which are from Latin American scientists and from several disciplines, a collection will be edited and published in a special volume of the Journal of Geophysical Research (JGR-Oceans). A Spanish version of the manuscripts will be considered for publication by IOC and CPPS.

The Conference Recommendations have been adopted by IOC, WMO and CPPS and will provide future guidance for the development of El Niño research, especially by Latin American Member States.

This Report was prepared by Dr. David B. Enfield, Chairman of the Joint IOC-WMO-CPPS Working Group on the Investigations of "El Niño" and Convenor of the Conference.

ANNEX I

PROGRAMME OF SCIENTIFIC SESSIONS

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- Large Scale Meteorological Processes Related to El Niño-Southern Oscillation
- Meteorological Aspects of El Niño - Southern Oscillation in the South-east Tropical Pacific and South America
- Physical Oceanographic Aspects of El Niño - Southern Oscillation
- Effects of El Niño on the Ecology of Lower Trophic Levels
- Effects of El Niño on Recruitment and Fisheries Processes
- Effects of El Niño on Birds and Mammals and Impacts on Human Activities

SESSION I

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Meeting Orientation, D.B. Enfield

An Overview of the El Niño Phenomenon in the South-east Pacific, R. Jordan

El Niño Events along the South American Coast and their Relation to the Southern Oscillation, J M Wallace

The Physical Oceanographic Aspects of El Niño: Observational and Theoretical Progress since 1970, P Lagos

The Biology of El Niño, R T Barber, R L Smith, R C Dugdale

A Review of the Effects of the El Niño Phenomenon on the Fisheries Resources of the South-east Pacific, S Avaria

SESSION II

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Predicting El Niño: Failures and Hopes, K Wyrtki

Experimental Forecasts of El Niño, S E Zebiak

Hindcasting/Forecasting of El Niño in the Eastern Equatorial Pacific based upon the Redistribution of Heat Content in the Western Tropical Pacific, W B White, S E Pazan

The Causes and Simulation of Local Equatorial Sea Surface Temperature Changes E B Kraus

New Linear Statistical Models of Equatorial SSTs, N E Graham, T P Barnett, J Michaelsen

Prediction of Tropical Pacific Rainfall Variations Using Observed Sea Surface Temperatures, B C Weare

Study of the Presence of Feedback during the ENSO Events, L Cid

Modeling of the Circulation in Coastal Upwelling Areas during the El Niño Event, C Carbonel

A Simple Dynamical Model for the Tropical Boundary Layer Flow and Divergence, R S Lindzen, S Nigam

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El Niño Occurrences over the Past Four and a Half Centuries, W H Quinn, V T Neal, S E Antunez de Mayolo

Eastern Pacific El Niño Episodes in the Context of the Global Southern Oscillation, E M Rasmusson, V E Kousky, H S Halpert

The 40-50 Day Oscillation and the El Niño/Southern Oscillation, K M Lau

Estimation of SST, Wind Speed, and Atmospheric Water Vapor and Liquid Water in the Tropical Pacific in 1982 from the Nimbus-7 SMMR, E A Francis, D B Chelton, E G Njoku

Variability of the Net Monthly Shortwave Radiation at the Ocean Surface during Tropic Heat (Oct 1983-Oct 1985), C Gautier

Variations in the Walker circulation for two contrasting years, M T Kayano, V B Rao, A D Moura

On the Changes in the Atmospheric Circulation over South America Associated with the 1982-83 El Niño, A Cornejo, C del Carmen, J Marengo

Remote Sensing of Water Vapor Convergence, Deep Convection, and Precipitation during the 1982-1983 El Niño, P. E. Ardanuy, C Prabhakara, H L Kyle

On the Use of Wind Profilers to Study Equatorial Dynamics and Climate, B B Balsley, W L Ecklund, D A Carter, A C Riddle, K S Gage

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Ideas about Possible Causal Mechanisms for Heavy Precipitation in Northwest Peru, J Marengo, A Cornejo

Characteristics of Extreme Rainfall Events in Northern Peru during the 1982-83 El Niño Period, R A Goldberg, G Tisnado, R A Scofield

The Evolution of Rainfall in Northern Peru during the Period January 1982 to December 1985, in the Coastal, Mountain and Jungle Regions, J A Lam, C del Carmen

Fluctuations of the Semi-permanent Marine Stratocumulus Layer along the Peru Coast between January 1982 and December 1985, Using Data from the Callao Radiosonde, C del Carmen, F A Quispe

Assessment of 1500 Years of Climate Variability and Potential of Long Term Record of ENSO Events from Andean Glaciers, L G Thompson, E Mosley-Thompson

An alluvial record of El Niño events from northern coastal Peru, L E Wells

Observations of El Niño Events at the Chilean Coast (20°S), R Fuenzalinda

Southern Oscillation and River Discharge in Tropical South America, L C B Molion, J C Moraes (introduced by M. T. Kayano)

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Oceanographic Variability off Ecuador Associated with an El Niño Event in 1982-83, E Cucalon

Propagation and forcing of high frequency sea level variability along the west coast of South America, M P Cornejo, D B Enfield

Effects of El Niño on the Eastern Boundary Circulation, T Paluszkiewicz, R L Smith, A Huyer

On the Mechanism of the Annual and Semiannual SST Fluctuation at the Eastern Equatorial Pacific and its Relationship to El Niño, P Lagos, D V Hansen, J M Wallace

Salinity along the Peru Coast during 1982-1986, O Moron, N Aliaga

The 1982/193 "El Niño" off the Northern Coast of Chile .1981 and 1984 Oceanographic Conditions, N Silva

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SESSION VI

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Biogenic Particle Fluxes in the Equatorial Pacific: Evidence for both High and Low Productivity of El Niño Effects, J Dymon, R Collier, S Roth

Cadmium in Corals: Reconstruction of Surface Ocean Fertility at Galapagos, G T Shen, E A Boyle

Effects of El Niño on New, Regenerated and Total Production in Eastern Boundary Upwelling Systems, R C Dugdale, F P Wilkerson, R T Barber

The 1976 El Niño: Biological Response off Ecuador, R Jimenez

Seasonal and interannual variations in nutrients and phytoplankton along the coast of Peru, F P Chavez

The El Niño Phenomenon and the Resources and Icthyoplankton off Peru, H Santander, O Sandoval

Spatial Distribution of the Macrozoobenthos and Filamentous Bacteria on the Northern Continental Shelf off Peru during and after the 1982-83 El Niño, H Salzwedel, A Z de Moreno, L A Flores, E Ch de Flores

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Important Changes in the Ecuadorian Pelagic Fisheries since El Niño 1982-1983 L S Maridueña

Interactions between the Populations of Anchovy and Sardine along the Peru Coast from 1970 to the Present. A Period of Great Changes, J. Zuzunaga

The effects of the 1982-83 El Niño on the Reproductive Process of the Peruvian Sardine, Sardinops sagax, sagax, N Peña

The Abundance of Sardine and Variation of some Environmental Factors off Baja California, Mexico, J L Castro, R Pacheco, C Gomez

El Fenómeno El Niño y su Influencia en los Recursos Pelágicos y la Pesquería del Norte de Chile (1983-1986), C Martínez, C Salazar, A Aranis, V Erbs

Biological effects of the 1982-83 El Niño off Oregon and Washington, U.S.A., W G Pearcy

Impact of El Niño 1982-1983 on the Commercially Exploited Invertebrates (Mariscos) of the Peruvian Shore, W Arntz, E Valdivia, J Zeballos

Changes in Oyster Condition Index with ENSO Events at 46ºN in an Eastern Pacific Bay, A Schoener, D F Tufts

Modelo de Stock - Reclutamiento de la población de Sardinops sagax, musica (Girard) de la Zona Norte de Chile. Efectos del Niño en la producción anual de huevos y tasas de mortalidad de los pre-reclutas, P Barría

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The Effects of the 1982-83 "EL Niño" on the Populations of Humboldt Penguins in Chile, B Araya

Population Levels of Guano Birds before and after the El Niño Phenomenon of 1982-83, H Tovar, V Guillen, D Cabrera

Fur Seal Foraging Behaviour during El Niño, P Majluf, M Goebel

Feeding of the Bryde Whale during the "El Niño", P Ramirez

The Socio-Economic Effects of the 1982-83 El Niño Phenomenon on the Principal Fisheries of Peru: An Essay on Comprehensive Evaluation, M Flores P.

Documentation of Large-Magnitude El Niño Events using Mollusks from Coastal Archaeological Sites, H B Rollins, D H Sandweiss, J C Rollins

Fossil Evidence for an Early Pleistocene Origin of El Niño off Peru, T DeVries

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El Niño and Indian Summer Monsoon Rainfall: Statistical Relationship, B Parthasarathy, N A Sontakke

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Sea Surface Temperature and Low-level Precipitable Water in the Tropical Pacific, E J Steiner, S J S Khalsa

Longitudinal Variations in Tropical Tropopause Properties in Relation to Tropical Convection and ENSO Events, K S Gage, G C Reid

Meteorological Aspects of El Niño - Southern Oscillation in the SE Tropical Pacific and South America

Cold Front Disturbances: A Way of Monitoring the "El Niño" Phenomenon, G O Obregon

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Analysis of a Meridional Vertical Section of the Atmosphere along the West Coast of South America, V Calle, C del Carmen

Precipitation Mechanisms in the Peruvian Territory During the 82-83 "El Niño" Phenomenon and in the Subsequent Rainy Periods, L Alfaro, E Jaimes

Cross Spectral Analysis of Data from Northern Peru, J Saavedra, R Mugica

Conjetura sobre Sincronía en Algunos de los Movimientos Planetarios que causan Variaciones en el Clima Mundial, G Fonseca-Truque

Hidrología del Fenómeno El Niño en el Perú, L Brea-Kaik

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Comparison of Inverted Echo Sounder and Hydrographic Data in the Galapagos Islands Region during the 1982-83 El Niño, S Chiswell, D R Watts, M Wimbush, J L Santos

Bravezas de Mar along the Peru Coast in Relation to El Niño, J Quispe, W Perona, E Miguel, J Suarez

Daily Upwelling and Turbulence Indices off the Peruvian Coast at Callao and Trujillo during the period 1953-1983, J Mendo, S Castillo, L Pizarro

Anomalies of Coastal Temperature and Sea Level along the Chilean Coast during the Last Three Decades, T R Fonseca

The Decline of the 1982-83 "El Niño" along the Coast of Peru, H Soldi

The annual and semiannual cycles in Peru coast SST, and their year-to-year variability, P Lagos, T P Mitchell, J M Wallace

Meteorological and Physical Oceanography Aspects of El Niño on the Mexican Pacific Coasts, I Galindo, J A Otaola, F Grivel, A Gallegos

An Optimum XBT Sampling Network for the Eastern Pacific Ocean, J Sprintall, G Meyers

Sea Level and Current Variability in the 5 Day Frequency Band at the Galapagos Islands, 1981-83, D W Denbo, D Halpern, S P Hayes

Baroclinic transports and their associated events off the Pacific coast of Canada during the 1982-83 El Niño, S Tabata

Variations of Subsurface Flows in the Eastern Pacific Transect from Costa Rica to Coco Island, C L Brenes, J E Coen

Observations on the Presence of the 1982-83 El Niño in Herradura Bay, Coquimbo, J Moraga, J Olivares

Peru coastal upwelling regimes near 5ºS and 10ºS during normal and El Niño times: 1981-1984, A Huyer, R L Smith, T Paluszkiewicz

Subsurface Temperature Patterns in the Eastern Equatorial Pacific during the El Niño Event of 1982-83, D V Hansen, T Gerish

Coastal currents along the west coasts of the Americas during El Niño, R L Smith, A Huyer, T Paluszkiewicz

On the source of 9-11 day propagating signals in coastal sea level off South America during the 1982-83 El Niño, D B Enfield, M P Cornejo

Variación del nivel medio del mar en el Ecuador, N Paredes

Influencia del Fenómeno "El Niño" sobre las Condiciones Termo-Salinas en Aguas Costeras Ecuatorianas, A Rodriguez R.

Effects of El Niño on the Ecology of Lower Trophic Levels

Effects of "El Niño" event on the zooplankton and icthyoplankton of Ecuadorian coastal water, 1983-1984-1985, M L Garcia, Y Ochoa

Primary Productivity in the Gulf of California during 1982-1985, J R Lara, E Valdez, C Bazan, J L Lara

Satellite Observations of Phytoplankton Variability during El Niño, G C Feldman

Modification of Copepod Populations in Relation to Physical Properties during the 1982-83 El Niño, A Dessier, J R Donguy

A BASIC Computer Program for the Classification of Phytoplankton in Relation to the El Niño Phenomenon in Colombia, F A Castillo

Nutrient Distributions in the Shelf Waters off Guerrero, Mexico during the 1982-83 ENSO Episode, F Ramos, A Gallegos, G de la Lanza

The 1983-84 "El Niño" Effects on Nutrients and Summer Phytoplankton of a Baja California Upwelling Zone, G Torres-Moye, S Alvarez-Borrego

Abundance and Distribution of Water Mass Indicator Dinoflagellates along the Peru Coast during El Niño Phenomenon of 1982-83, N Ochoa, O Gomez

The presence of Red Tides in the Central Zone of Chile Associated with the 1982-83 "El Niño" Phenomenon, P Muñoz

Estudio comparativo de la alimentación de la caballa (Scomber japonicus) en 1979 y durante El Niño 1982-83, S G Sanchez, J J Velez

An Investigation in the Nutritional Strategies of the Deep Water Microbial Microaerophile Thioploca, C G Bryden

Equatorial Upwelling Processes in the Galapagos Islands after the 1982-83 "El Niño", R Jimenez, P Intriago

The El Niño Event and its Influence on the Composition of Zooplankton off Peru, S Carrasco, H Santander

A Comparison of Nitrogen Dynamics Observed during El Niño years at Point Conception, California and 15ºS, Peru, F P Wilkerson, R C Dugdale

The Use of HPLC for Evaluating El-Niño Effects on Phytoplankton Distributions and Composition, M Ondrusek, R R Bidigare, J M Brooks

Nota Sobre la Presencia de Especies Zooplanctónicas como Indicadores de Aguas Cálidas en el Norte de Chile, V Asencio, A Mujica

Contribución al Conocimiento del Fitoplancton Nerítico de la Costa Pacífica Colombiana (Sector Tumaco-Cabo Manglares), H J Quiros

Fluctuations in the Abundance of Brown Macro Algae in the North of Chile between 1979 and 1986, J J Tomicic

Pterópodos y heterópodos del mar ecuatoriano durante 1985 y 1986, M Cruz

The Nitrate-Silicate Relationship during the 1982-83 El Niño, O Guillen

Chlorophyl in the Upwelling Areas of Chimbote and San Juan during the 1982-83 El Niño, R Calienes

Effects of El Niño on Recruitment and Fisheries Processes

The Fishery of the Common Sardine (Clupea bentincki) and the 1972-73 El Niño, C Veloso, A Arrizaga

Effect of El Niño on the Distribution and Recruitment of the Peruvian Hake (Merluccius gayi peruanus), M Espino, W Urquizo

Sea Surface Temperature and Salinity Variations off Northern Chile during the El Niño in Relation to Fish Fluctuations, J R Cañon

Feeding Variations of the Sardine (Sardinops s. sagax) in the years 1980-1984 along the Peru coast, A Alamo

Changes in the Thermal and Saline Structures in the Northern Zone of Chile and their Relation to the Distribution of Spanish Sardine (1981-1986), J L Blanco, R Kelly, J Castillo

Effects of the 82/83 El Niño Phenomenon on the Titi Shrimp (Xiphopeneus riveti) along the Peru coast, J Mejia, E Valdivia, M Mendez, J Castillo

Some Evolutionary Implications of Protracted El Niño Events in the Colonization and Ecological Balance of Fish Populations in the Galapagos Archipielago, J S Grove

Disappearance of the Giant Squid (Dosidicus gigas) Fishery in the Gulf of California and its Possible Relation to Overfishing and the Effects of "EL Niño", E M Ramirez, F Magallon

Recuperation of the Coastal Communities of the Northern Zone of Chile after "El Niño" phenomenon 1982-1983, R Soto

Un Análisis. Sobre las Causas del Colapso de la Pesquería de Anchoveta (Engraulis ringens) Realizado en la Zona Norte de Chile, E Yañez, M A Barbieri, O Barra

Biological Effects off Ecuador during the 1982-83 El Niño, R Jimenez

Effects of El Niño on Birds and Mammals and Impacts on Human Activities

Oscillation of Macrobenthos in Shallow Waters of the Peruvian Central Coast Induced by El Niño 1982-83, J Tarazona, H Salzwedel, W Arntz

Impact of the 1982-83 El Niño Phenomenon on Agricultural Production in Peru, W A Sanchez

El Niño and Fur Seal Lactation Strategies, P Majluf, F Trillmich

Fluctuations in the Principal Components of the Shallow Water Ecosystem along the Central Peru Coast during 1982-84, J Tarazona, H Salzwedel, E Canahuire, C Cordova

Demographic, Reproductive and Physiological Changes in the Marine Bird Populations in the North of Chile caused by the 1982-83 El Niño, C G Guerra

The Impact of the 1982/83 El Niño-Southern Oscillation on seabirds in the Galapagos Islands, C A Valle, F Cruz, J Cruz, G Merlen, M Coulter

Note: Names underlined indicate authors and/or participants who introduced corresponding papers.

ANNEX II

RECOMMENDATIONS OF THE AGU-IOC-WMO-CPPS CHAPMAN CONFERENCE: AN INTERNATIONAL SYMPOSIUM ON "EL NIÑO"

Recommendation Number	Title
Recommendation 1	Meteorology
Recommendation 2	Physical Oceanography
Recommendation 3	Biology
Recommendation 4	Socio-Economic Aspects
Recommendation 5	Data Exchange
Recommendation 6	Monitoring and Prediction of the El Niño Phenomenon in the South-East Pacific: Application to Development (UNDP-IOC-CPPS Regional Project)
Recommendation 7	Spanish Publication of Select Symposium Presentations
Recommendation 8	Long-Term Studies of "El Niño"

Recommendation 1

METEOROLOGY

Considering that a detailed knowledge of meteorological conditions is required in order to make a definitive progress in the description and understanding of the atmospheric and oceanographic process associated with disruptive regional El Niño anomalies, and that scientists interested in continental-scale synoptic climatological studies have noted with satisfaction the data and information exchange programme initiated through the ERFEN Climate Analysis Bulletin,

Recommends

(i) that efforts be intensified to improve the collection and exchange of real-time meteorological data from the entire South American continent and adjacent oceanic regions through the GTS,

(ii) that an adequate mechanism be provided for the collection and dissemination of required monthly summary climatological data through GTS, in addition to that currrently provided through CLIMAT exchange such as sea surface temperature and other marine data from coastal stations and other coastal platforms. (The CPPS's ERFEN Climate Analysis Bulletin seems to be a convenient medium for the distribution of these data sets.),

(iii) continued exchange of South American historical data of interest to scientists studying the synoptic climatology of the continent including its relationship to El Niño anomalies, and

(iv) that the feasibility of establishing a regional South American meteorological and climate analysis and research center be examined.

Recommendation 2

PHYSICAL OCEANOGRAPHY

Recognizing that a substantial knowledge of oceanic conditions in the Pacific Ocean offshore of the South American continent is required in order to make definitive progress in the description and understanding of the transport processes associated with the evolution of normal and El Niño conditions; and

Noting with satisfaction the initiation of a programme of data and information exchange through the ERFEN Climate Analysis Bulletin and the increased interest by South American scientists in physical oceanographic studies in the tropical and offshore zones,

Recommends that efforts be continued to:

(i) improve the collection and exchange of "real-time" physical oceanographic data;

(ii) assemble and disseminate regional historical data sets related to the description of the El Niño phenomenon;

(iii) maintain existing time series and to identify new sites for effective time series measurement opportunities. (Time-series include fixed stations reporting "real-time" data on a continuing basis, and hydrographic and XBT sections repeated on a monthly or bi-monthly basis for several years);

(iv) sample selected nutrient observations as well as biological parameters when possible; and

(v) examine the possibility of installing a satellite-transmitting sea-level and SST station on Malpelo Island, combined with monthly or bi-monthly hydrographic sampling along the Buenaventura-Malpelo Island route.

Recommendation 3

BIOLOGY

Considering that the importance of biological investigations in understanding the consequences of El Niño in reducing the negative effects and in better utilizing the beneficial changes needs the development of the following three general areas of research: (a) standardization of methods; (b) biological time-series of economic and/or ecologically important species; (c) population dynamics, especially related with reproduction and recruitment process studies of fish and invertebrates;

Recommends that

(i) workshops be organized to address specific habitats or taxonomic groups, for example, the different responses of rocky shore communities to El Niño on a latitudinal gradient,

(ii) priority be given to programmes carried out from the shore where the costs involved are considerably lower than when using research vessels,

(iii) working methods be standardized particularly in the ERFEN region for a better understanding of the changes associated with El Niño,

(iv) investigations of the early life stages of commercially important fish and invertebrates be emphasized in relation to environmental parameters, to predict the recruitment success under El Niño and non-El Niño conditions,

(v) experiments be initiated under simulated El Niño conditions to determine how reproduction, growth and survival of fish and invertebrates are affected by the phenomenon,

(vi) continuous biological time-series be accumulated to adequately statistically describe the El Niño and non-El Niño conditions, in particular to achieve the full utility of Indicator species,

(vii) statistics on shellfish be improved for management purposes, mainly for rectifying the confused nomenclature and for providing information on catch-per-unit of effort,

(viii) investigations be increased on both local species which flourished under El Niño conditions and those of commercial importance which invaded the area during the event, and

(ix) with the aim of supporting the biological studies, physical studies of temperature, salinity, oxygen, and currents, be carried out principally on the shelf. These studies should provide continuous time-series by instruments mounted on the bottom and in mid-water depths down to at least 100 m.

Recommendation 4

SOCIO-ECONOMIC ASPECTS

Considering that El Niño is a phenomenon of a recurrent nature and that it constitutes a most drastic alteration of natural order in the continent, in the sea and coastal zones of the region,

Recognizing the importance of the El Niño phenomenon to the South American Pacific Member States, and that it must be viewed in terms of its impacts,

Noting the importance of the socio-economic evaluation of the effects of the phenomenon in the various productive activities of goods and services of the South-east Pacific countries, mainly in the sectors of agronomy, housing, road systems, fishing and health,

Further noting the desirability to reduce and/or eliminate the negative effects and to take advantage of those cases where the effects are positive,

Recommends

(i) quantitative and appraised evaluations of the negative effects (damage) and positive effects (benefits) of the phenomenon by economic sectors and geographical areas, using the "input product matrix" and the macro-economical ex-post analysis to allow the governments and the productive agents, both public and private, on funding actions, reconstruction of infrastructure and re-ordering of activities. (Such evaluations must be completed with the information existing from past occurrences of the phenomenon), and

(ii) the design and development of institutional arrangements to allow the Integration of the national entities responsible for the investigation, prevention, evaluation and reconstruction, optimizing a surveyance plan of the effects of the phenomenon starting from the alert signals up to the most trustworthy predictions in order to reduce the adverse effects and take advantage of the beneficial effects within the context of the planning and managements of the coastal and maritime zones.

Recommendation 5

DATA EXCHANGE

Considering that proper studies of El Niño require data from many sources which should be available on a timely basis to the international scientific community,

Recognizing that the CPPS/ERFEN "Boletín de Análisis Climático Pacífico Oriental Sudamericano" has proven to be an effective mechanism for exchanging analyses and summaries of data,

Recommends

(i) that countries both within and outside the ERFEN region give high priority to submitting to the publication selected sets of oceanographic and meteorological data according to requirements in the region;

(ii) that a mechamism be sought to establish an electronic mail system among the ERFEN countries; and

(iii) that all data collected in the region by platforms, fixed buoys and ships, that are transmitted via satellite, be put into the GTS, and that this system be improved to make the data available to interested countries.

Recommendation 6

MONITORING AND PREDICTION OF THE EL NIÑO PHENOMENON IN THE SOUTH-EAST PACIFIC: APPLICATION TO DEVELOPMENT (UNDP-IOC-CPPS REGIONAL PROJECT)

Recognizing the great adverse socio-economic impact produced by the 1982-1983 El Niño, particularly in relation to the coastal communities, fishing industry and agriculture,

Noting that countries participating in ERFEN require international support to fully participate in the regional investigations,

Further noting the intimate relationship existing between the regional expression of the El Niño phenomenon on the Pacific-wide and global scales,

Gives its fullest endorsement of the UNDP-IOC-CPPS Regional Project on El Niño, and

Recommends

(i) that Member States participating in the IOC-WMO-CPPS Joint Working Group on Investigations of El Niño actively encourage their national representatives to UNDP to support this important initiative, and,

(ii) Invites UNDP to keep this proposal in high priority within the context of its Fourth Cycle Funding Programme (1987-1991).

Recommendation 7

SPANISH PUBLICATION OF SELECT SYMPOSIUM PRESENTATIONS

Noting the large scientific community performing investigations on El Niño in Spanish-speaking countries,

Recognizing the benefits of broadening the dissemination of the symposium results,

Recommends that AGU, IOC and CPPS support and facilitate translation into Spanish, publication and distribution of selected symposium presentations, particularly those most relevant to the South-east Pacific region.

Recommendation 8

LONG-TERM STUDIES OF "EL NIÑO"

Recognizing that the El Niño is a recurrent phenomenon which can be evidenced in historical, archeological and geological records; and the value of considering historical, archeological and geological evidence of El Niño events to the understanding of the phenomenon,

Recommends

(i) that scientific communication between those studying El Niño on long-time scales (hundreds to millions years) and scientists who conduct process-oriented studies of the phenomenon during the most recent fifty years, be improved,

(ii) that the meaning of El Niño in pre-historical times as evidenced in proxy time-scales, be clarified,

(iii) increased research efforts on specific time periods showing extreme conditions, or which for other reasons are interesting but lack sufficient data, and

(iv) similar studies on "non-El Niño" periods, as being potentially informative of the underlying processes, be conducted.

ANNEX III

ABSTRACTS OF SCIENTIFIC PAPERS

SESSION I

INTRODUCTIONS, OVERVIEW AND REVIEWS

An Overview of the El Nino Phenomenon in the Southeast Pacific

by
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The eastern tropical boundary of the Pacific Ocean harbors an ecosystem of high interannual variability, with profound modifications of the biota during occurrences of El Nino. One consequence of the variability, and in part of intense fisheries activities, is the alternate predominance of various populations of planktiferous fish.

Mentioned are the scientific advances made in the study of El Nino, the large oceanic and continental scale of the event and the socio-conomic impact of man's activities both on land and at sea. The ecological concept of El Nino, in which ocean climate changes result from a cause-effect sequence and illicit responses from the components of the various trophic chains, is reviewed.

The socio-economic impacts of El Nino in the southeast Pacific, especially the 1982-83 event, are reviewed and the social and governmental responses, as well as those of the international community, are analyzed. Particular reference is made to the ERFEN Programme as a genuine cooperative response of the regional countries to study the El Nino with funds from their governmenets and the support of the specialized UN agencies.

Reference is made to the wealth of resources presently available to science, to the problem of access to those resources by the developing countries, and to the significance of the present El Nino Symposium that, 12 years following the first symposium, marks an important milestone in scientific progress and international cooperation.

El Nino Events along the South American Coast and their relation to the Southern Oscillation

by
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Meteorological aspects of El Nino events are reviewed, with emphasis on relations between conditions along the South American coast and the planetary scale pressure fluctuations associated with the Southern Oscillation. Although El Nino is often accompanied by negative pressure anomalies in the Southeast Pacific and positive anomalies over Australia and Indonesia, this relationship is not as strong as relationships between other variables in the El Nino/Southern Oscillation phenomenon. Despite the fact that the most pronounced positive SST

anomalies along the South American coast tend to occur in March-June toward the end of the warm season, coastal SST is actually most strongly correlated with the Southern Oscillation during the cold season (July-November).

Coastal offshore SST are strongly correlated, but it is puzzling that coastal SST is more strongly correlated with SST along the ship track to the west of the Galapagos than with SST closer to the coast. Cold season low cloudiness exhibits a strong negative correlation with local SST, and warm season rainfall is positively correlated with local SST. During the cold season pressure in the eastern equatorial Pacific exhibits a strong negative correlation with local SST and a strong positive correlation with pressure throughout the southeast Pacific and with the conventional indices of the Southern Oscillation. For some reason, these relationships are much weaker during the warm season. Southward excursions of the eastern Pacific ITCZ during El Nino years are also most evident during the cold season.

Hence the phenomena related to El Nino during the warm season are somewhat distinct from the basin-wide Southern Oscillation phenomenon, and deserve special emphasis in their own right.

The Physical Oceanographic Aspects of El Nino: Observational and Theoretical Progress since 1970

by
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The purpose of this paper is to review the key observational and theoretical advances that have been made in understanding the El Nino phenomenon in the tropical Pacific in the last 15 years. This is done by tracing the succession of descriptive and modelling results that have emerged over this period, beginning with the concepts of Bjerkenes,generally accepted in 1970, and ending with the most recent findings. The reviewed advances represent an evolution in our thinking that has been primarily stimulated by two major El Nino episodes during this time frame: 1972-73 and 1982-83. These particular events provide the principal context for the discussion, which ends by pointing out those processes that remain to be understood more fully in the future.

The Biology of El Nino

by
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The relatively well-developed physical models of the ENSO process and numerous physical observations of the 1976 and 1982/83 El Nino events can be related to the complex biological changes that took place during these anomalies. This review relates the mesoscale oceanographic processes of El Nino to specific positive and negative responses of the biota. The analysis focuses on how the physical anomaly affects the biota through 1) direct thermal effects, 2) behaviorally-mediated migration, 3) food stress or 4) reproductive failure. Quantification

of the decrease in new nutrient supply and understanding how this decrease affects primary productivity provides new insight into the largescale flux of carbon and nitrogen in the coastal upwelling and eastern boundary current system during both normal and El Nino conditions.

A Review of the Effects of the El Nino Phenomenon on the Fisheries Resources of the Southeast Pacific

by
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A review is given of the alterations produced in the coastal upwelling ecosystem of the southeast Pacific in association with "El Nino" events, with emphasis on the fisheries resources of the region. In relation to these effects, we present the results of observations on the behavior of the principal pelagic and demersal resources undertaken by the countries of the region in the context of the cooperative research programme on "El Nino" initiated in 1980 (ERFEN).

The impact of "El Nino" on the fisheries resources has been distinct in each of the occurrences after 1950. The 1957-58 episode affected the behavior and distribution of anchoveta (Engraulis ringens) but with no direct effect on the abundance of the resource. The event of 1965 caused a drastic decrease in anchoveta landings, but the impact was brief and subsequent catch levels recovered and increased. The effects of the 1972-73 "El Nino" were more serious and prolonged. Adverse environmental conditions, together with an intensive commercial exploitation produced the collapse of the anchoveta fishery, which did not recover. Other species increased, with the dominance of sardine (Sardinops sagax) and jack mackerel (Trachurus murphy). The low intensity episode of 1976 accelerated the decline of the anchoveta and the increase of other pelagic species. The 1982-83 El Nino affected a wider variety of fisheries resources, the kind and intensity of the effects depending on species and being manifested mainly by changes in distribution patterns, alterations of certain physiological conditions, and reproduction and survival failures in eggs and larvae.

Based on the important data collected through research carried out during recent "El Nino" events, some guidelines for future studies of the subject are suggested.

SESSION II

MODELLING AND PREDICTION OF THE COUPLED
OCEAN - ATMOSPHERE SYSTEM

Predicting El Nino: Failures and Hopes

by
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The difficulties of predicting a coupled ocean-atmosphere system will be assessed and critically evaluated. Reasons of failures and successes of past predictions will be evaluated, giving examples of the first prediction for 1975, and of the 1976 and 1982-83 events. Attempts to anticipate El Nino developments in 1986 will be reviewed. Predictions based on precursors are notoriously uncertain because these precursors are usually ill-defined.

Numerical models will play an increasingly important role in future predictions, but one will have to be critical of their forecasts, because they can only be based on past experience which may not contain the entire wealth of possible information. Consequently, a prediction of El Nino may be an elusive task if the ocean-atmosphere system is basically of random behavior and the evolution in time of its behavior is non-stationary.

Experimental Forecasts of El Nino

by
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Forecasts of El Nino were made using a coupled atmosphere-ocean model for the tropical Pacific region. Initial conditions for the forecasts were determined by forcing the ocean component with observed wind stress anomalies (F.S.U. analysis) from January 1964 onward, and calculating the equilibrium atmosphere model response to the resulting sea surface temperature anomaly field. Forecasts were made monthly for each year since 1970, and run ahead for the following two years. In 80% of the cases, all the individual forecasts for 1 year ahead agreed and were correct, both for El Nino years and non-El Nino years. The other cases were not incorrect but were ambiguous. For the 2 year-ahead forecasts, 70% were unequivocal and correct, and the rest ambiguous. Analysis of the results indicates that the primary memory of the coupled system resides in the upper ocean thermal structure. The magnitude of the integrated equatorial heat content anomaly provides a good indication of those times when the forecasts are not likely to be reliable 1-2 years in advance.

Hindcasting/Forecasting of El Niño in the Eastern Equatorial Pacific based upagreon the Redistribution of Heat Content in the Western Tropical Pacific

by
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The redistribution of both observed and model heat content in the western tropical North Pacific during the 23-year period 1964-1986 is examined for its ability to hindcast and forecast ENSO events of this period. Complex EOF analysis is applied to the Onset Phase of ENSO events occurring 1-3 years prior to the Mature Phase of the ENSO events in 1965-66, 1968-69, 1976-77 and 1982-83: this analysis is used to determine the characteristic redistribution of heat content during this Onset Phase. The first complex EOF explained 61% and 60% of the interannual variance of observed and model anomalous dynamic height, respectively, over the 23-year period. This analysis finds both the observed model and heat content redistribution in the western tropical North Pacific to be characterized by wind-driven westward propagating, baroclinic Rossby waves, having a remarkably stable period of 4 years over the 23-year period. The complex time sequences from this analysis are used to construct a hindcast index that yields peak values one year prior to the Mature Phase of ENSO events over the 23-year period. The index does not peak when ENSO event did not occur. This index achieves these high values due to the incidence upon the maritime coast of Asia in fall/winter of a positive anomaly in heat content propagating from the ocean interior at Rossby wave speeds. The model heat content redistribution has the advantage over the observed heat content redistribution of being available in near real time (i.e., within a month of the present), which makes it useful in providing a near-real time forecast of future ENSO events. Application of this forecast index to the upcoming year is discussed.

The causes and Simulation of Local Equatorial Sea Surface Temperature Changes

by
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The work "local" in the title implies that large scale circulation changes are accepted as given.

The equatorial sea surface temperature is a crucial link in the coupled ocean-atmosphere system. It is a function of the surface energy flux, horizontal and vertical advection, mixed layer depth, attenuation of solar radiation, etc. Various authors have emphasized one or the other of these variables in their models. The present paper presents a survey and sensitivity analysis of the role of these different processes.

Equatorial surface layers often contain vertically sheared currents. As they cannot be simulated by integral mixed-layer models, the sensitivity studies are based on the "transilient" method. The concept of transilient turbulence will be described briefly during the talk. It involves the parameterization of transports by a spectrum of eddies. A more detailed account has been given by Stull (1984; J. Atmos. Sci., 41; 3351-3367). Other oceanic applications are the subject of a paper by Stull and Kraus (submitted to J. Phys. Oceanogr.).

New Linear Statistical Models of Equatorial SSTs

by
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We have constructed two sets of linear models for predicting equatorial Pacific sea surface temperatures (SSTs) from the tropical wind field and from the near-global sea level pressure (SLP) field. Both analyses provide insights into the potential predictability of SSTs and the evolution of the SLP and wind fields through he ENSO cycle.

The models were constructed using a combination of extended empirical orthogonal function (EEOF) analysis and canonical correlation analysis, a new approach in air/sea statistical models. Forecast skills were estimated using a simple cross-validation scheme.

The results show that the tropical wind field model does well at forecasting SSTs during much of the year, at leads of one three months. During these periods, the models are in agreement with the theory that Kelvin waves generated by remote wind forcing are responsible for the observed SST changes. However, the model does not do well at forecasting the magnitude of the rise in SST at the onset of El Niño, suggesting that large-scale wind anomalies are not responsible for the initial temperature jump.

The SLP models were constructed for lead times of seven to thirteen months. While these models perform poorly in a least square sense, they can provide useful early warning guidance when applied with a simple decision rule. Our analysis shows that the model predictability comes from a pattern of SLP anomalies moving out of the Indian Ocean into the southwest Pacific about a year prior to the onset of El Niño.

Statistical composites created as part of the modelling efforts clearly show that slowly propagating anomalies in the atmosphere have important climatic effects at hemispheric spatial scales.

Prediction of Tropical Pacific Rainfall Variations Using Observed Sea Surface Temperatures

by
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Over the tropical oceans rainfall variations may be quite accurately inferred from satellite measured estimates of outgoing long wave radiation (OLR). There is also evidence that the OLR over the central equatorial Pacific may be prescribed using measured sea surface temperatures (SST). A constrained multiple linear regression technique is utilized to estimate the best statistical models to predict OLR for 25 points in the region 20°S - 20°N, 140°E - 110°W using data for the period June 1974-February 1984. The constrained multiple regression equations minimize the prediction errors associated not only with a single spatial point but also those associated with the broad patterns of variations of OLR. The resultant specification equations are evaluated in terms of both hindcast and forecast skills.

In general the best models are found for specifying OLR near the equator in the central ocean. The most influential ST are in the regions to the east. The poorest specifications are for the OLR in the western Pacific. The possible use of these techniques in specifying OLR and hence rainfall for the pre-satellite era is discussed.

Study of the Presence of Feedback during the ENSO Events

by
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The difference between the monthly means of sea level pressure (SLP) at Tahiti and Darwin were used to obtain an index of the Southern Oscillation (SOI). This index was used as input to fit a transfer function model (TFM) using as output the sea surface temperature (SST) at Puerto Chicama. Data since 1951 until 1983 was used.

The analysis showed that a TFM is not appropriate to fit the data, due to the presence of significant values of cross-correlation between the input and output for negative lags. A model including feedback parameters was considered and the goodness of fit is tested using simulation and several test statistics.

Modelling of the Circulation in Coastal Upwelling Areas during the El Niño Event

by
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The modification of the circulation in coastal upwelling areas during the 1982-83 El Niño episode is studied with a non-stationary, bi-dimensional numerical model with two layers. This model, originally conceived for open ocean regions, involves convective accelerations, model interface stresses and turbulent diffusion. Non-reflecting boundary conditions are specified at the open boundaries of the model. The dynamic behavior of the coastal upwelling process is described as a response to the wind field and the large scale pressure gradients considered.

A Simple Dynamical Model for the Tropical Boundary Layer Flow and Divergence

by
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This paper examines the validity of the following hypothesis: that the sea surface temperature (along with its gradients) largely determines the boundary layer (planetary) divergence and therefore the moisture flux convergence too over the tropical oceans. A simple shallow water model applied to the well-mixed tropical boundary layer (capped by the trade inversion) is driven by the seasonally averaged 1000 mb air temperature field observed during the FGGE period, and the solutions (the zonal and meridional wind and the divergence) are compared with the corresponding seasonally averaged fields obtained also from the same data set. Over the tropical oceans, and in particular, over the tropical Pacific (from 20°S to 20°N), the model solutions compare quite favorably with the observations

This simple dynamical model, for a given set of model parameters, also simulates with some success the inter-seasonal variability of the lower tropospheric ($p > 700$ mb) tropical circulation over the Pacific. To the extent that this model contains the dynamics relevant to this problem, it suggests that the divergence in the well-mixed tropical boundary layer is determined mostly by surface forcing and decoupled from the dynamics of the middle and upper troposphere.

SESSION III

LARGE SCALE METEOROLOGICAL PROCESSES RELATED
TO EL NINO - SOUTHERN OSCILLATION

El Niño Occurrences over the Past Four and a Half Centuries

by
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A large number of books and articles involving five different languages have been reviewed to obtain pertinent information on El Niño events that occurred over the past four and a half centuries. Since this information refers strictly to El Niño occurrences, it is based on evidence obtained from the west coast region of northern South America and its adjacent waters. Determinations of the relative strengths of events are based on such considerations as degree of physical damage and destruction, amounts of rainfall and flooding, mass mortality of endemic marine organisms and guano birds, extent of invasion by tropical nekton, rises of sea temperatures and sea levels, effects on coastal fisheries and fish meal production, etc. Emphasis has been placed on the strong and very strong events. For example the 1891, 1925-1926 and 1982-1983 El Niño events are considered to be very strong; whereas, the 1940-1941, 1957-1958 and 1972-1983 events are placed in the strong category. Over our period of study we noted about 40 events that could be classified in the strong-very strong categories. Information is included to substantiate very strong categorization. The broad perspective provided by this literature survey caused us to revise several of our earlier evaluations on event intensities.

This study was carried out in order to better understand how these events evolve, to what extent involved areas may be affected, relative strengths of the various events, and frequency of occurrence of events in the various intensities. We were also interested in identifying some of the longer term (decadal or longer) changes that occur over this period.

Eastern Pacific El Niño Episodes in the Context of the Global Southern Oscillation

by
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Using data from 1952-86, it is shown that pronounced patterns of SST anomalies across the equatorial Pacific are related to large spatial scale, interannual time-scale SST and circulation anomalies around the

entire equatorial belt. These slowly evolving patterns are a manifestation of major swings in the Southern Oscillation. The low-level wind anomalies in the Indian Ocean-Central Pacific sector usually have the appearance of direct thermal circulations (anomalous easterly component to the east, anomalous westerly component to the west of regions of significant positive SST anomalies). These features often remain nearly stationary for several seasons, but inevitably migrate eastward with the development of an ENSO episode.

The evolution of these fields during a "typical" ENSO episode is described in the context of the two-phase development hypothesis proposed by Rasmusson and Wallace (1983). The fundamental differences between the eastern Pacific pattern of development during a warm episode, and that farther west is emphasized. Finally, the pattern of SO-equatorial Pacific SST fluctuations since 1950 is examined, and case-to-case differences in ENSO development are discussed.

The 40-50 day Oscillation and the El Niño/Southern Oscillation

by
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The tropical atmosphere possesses two prominent modes of low frequency oscillation, i.e., the El Niño/Southern Oscillation (ENSO) and the so-called 40-50 day oscillation. While the former is the strongest interannual signal ever observed in the earth's atmosphere-ocean system, the latter is the strongest intraseasonal signal so far observed in the tropical atmosphere. In this paper, the most up-to-date observations and theories of the 40-50 day oscillations are reviewed. These include results from empirical data analysis, GCM outputs and theoretical studies. For the observation aspects the structure propagation, seasonal modulation, regional and global characteristics will be summarized. The strong contrast between these characteristics over the tropical western and eastern Pacific and their effect on the oceanic anomalies will be discussed.

Theories of the oscillation and their possible validation or falsification against observations will be discussed. Judging from the remarkable similarity between observed atmospheric circulation anomalies in the 40-50 day oscillation and the ENSO, and the mechanism for the origin of the two phenomena understood so far, it is possible that a connection may exist between the 40-50 day oscillation and ENSO. In a heuristic sense, each 40-50 day oscillation may be visualized as a mini-ENSO or a potential ENSO realization. The impact of such connection, if it exist, on the possible prediction of ENSO, is also discussed.

Estimation of SST, Wind Speed, and Atmospheric Water Vapor and Liquid Water in the Tropical Pacific in 1982 from the Nimbus-7SMMR

by
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Raw data from the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) have been reprocessed using new algorithms for the tropical Pacific for a period during the 1982-83 El Niño. From measurements of passive microwave radiation we derive fields of SST, surface wind speed, atmospheric water vapor and liquid water content. The data are presented as monthly averages on a 1° x 1° grid in the region 50°S to 50°N and 130° to 290°E. Data processed so far cover the period December 1981 through December 1982 corresponding to the onset and maturation of the first anomaly peak during the ENSO episode.

The observations of these geophysical variables are unique because of their extensive areal coverage of the tropical and extra-tropical Pacific which are resampled every 6 days. Microwave satellite data are not subject to atmospheric attenuation to the degree that I-R and visible wavelength data are. This is an advantage during this period of anomalous and large scale convection associated with shifting convergence zones throughout the equatorial Pacific. Distributions of atmospheric water vapor, integrated from the sea surface to the satellite height of 955 km, can accurately map these migrating convective cells. The satellite-derives SST fields reveal smaller scale structure than the smoothed fields derived from sparse ship observations and are of interest to ocean-atmosphere modellers using SST as a model parameter. These SST, wind speed, water vapor and liquid water content fields will be described and examined statistically to investigate the temporal and spatial structure of the variability during the development of the 1982)83 El Niño.

Variability of the Net Monthly Shortwave Radiation at the Ocean Surface during TROPIC HEAT (Oct 1983-Oct 1985)

by
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The Downwelling and the Net Shortwave radiation (DSW and NSW) at the ocean surface have been computed from visible geostationary satellite data during TROPIC HEAT, on a daily basis.

These daily satellite estimates have been compared with surface measurements and the statistics of the comparisons are presented and discussed.

Monthly mean fields have been produced from these daily estimates for a region extending from 50°N to 10°S and 110°W to 150°W for a two-year time period and are used for our analysis of the annual and inter-annual variability.

The analysis of the seasonal evolution of DSW over the two-year period displays very similar features each year, i.e. a slow evolution of the fields resulting from the combined effects of sun zenith angle changes and major convective activity displacements. The DSW minima are associated with the major convergence zones (i.e. ITCZ and SPCZ) and are encountered at about 7-8°N during the Northern hemisphere fall and winter and at about 10°S during the summer. The late winter-early spring period appears to be a transitory period during which the fields are more variable in space and time, in association with the collapse of the cold tongue. The equatorial band, from about 2°N to 2°S, is the locus of a DSW maximum throughout the entire period.

Comparisons of the two years display small differences in the magnitude of the fields (i.e. smaller values) of DSW the first year (Oct 1983-Sept 1984) and small displacements of the major convective zones.

The evolution of DSW will also be discussed in relation with the evolution of the sea surface temperature fields computed from AVHRR infrared observations during the same time period.

Variations in the Walker circulation for two contrasting years

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The severe drought conditions observed during 1983 over large extensions of the tropical lands were associated with the 1982-83 El Niño event. In contrast, in 1984, above normal rainfall was observed over these areas. We calculated the Walker circulation for these two contrasting years. The intensity and location of the rising and subsiding limbs of the Walker circulation seemed to be consistent with the anomalies of outgoing long wave radiation and the rainfall anomalies. We examined for the two contrasting years observed atmospheric circulation patterns in the context of the currently acceptable theoretical notions. We found that some of the observed characteristics could be explained in terms of atmospheric response to tropical heat sources. We found that the north-south migration of ITCZ played an important role to modulate the tropical precipitation.

On the Changes in the Atmospheric Circulation over South America associated with the 1982-83 El Niño

by
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During the El Niño of 1982-83 there occurred torrential rains in northwest Perú as well as drought conditions on the altiplano of Perú and Bolivia. These anomalies are associated with important changes in the atmospheric circulation over South America. We have made a diagnosis of such changes by using synoptic data from weather stations located along the east flank of the Andes cordillera in Perú, as well as other synoptic information from South America during certain days within the event.

Preliminary results indicate that, at least during certain periods of abundant precipitation in northwest Perú, the thermal low pressure area normally located along the Argentine flank of the cordillera penetrated anomalously northward to the latitudes of northwest Perú, following the east flank of the Andes. We speculate that this anomalous penetration is associated with the intensification of the southern hemisphere jet-stream.

Remote Sensing of Water Vapor Convergence, Deep Convection, and Precipitation during the 1982-1983 El Niño

by
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Deep tropospheric warming and mass flux, produced by the convection associated with organized tropical precipitation, is responsible on monthly and seasonal time scales for the presence of the Hadley and Walker circulations. In ENSO event years such as 1982-83, in response to a perturbed SST field in the equatorial Pacific Ocean, a major displacement in the ascending branch of these thermally-direct, planetary-scale cells occurs. As the northern winter monsoonal rainfall minimum develops over the tropical Pacific Ocean near the dateline, normal precipitation over Indonesia and the Amazon and Congo River valleys is suppressed. Later, as the SST maximum approaches the coast of South America, flooding occurs over Ecuador. As a direct result of the induced anomalies in the general circulation, droughts are caused not only in Indonesia, but also in northern

Australia and in the northern subtropical Pacific Ocean along an axis from the Philippines to Hawaii.

The Scanning Multichannel Microwave Radiometer (SMMR- on board the Nimbus-7 spacecraft has been used to derive estimates of atmospheric water vapor. The correlation between the satellite and verifying radiosonde data is better than 0.83 at all stations considered. The Earth Radiation Budget (ERB) experiment flown on the same satellite observes the terrestrial net radiation, albedo, and Outgoing Longwave Radiation (OLR). The OLR fields have been related to the 200 mb divergence fields in the tropics during FGGE with a correlation of 0.8. The derived relationship has been successfully extended to realistically map the irrotational flow and divergent circulations present in the troposphere both prior to and during the 1982-83 ENSO event.

Together, the two data sets yield a joint estimate of the convergent flux of water vapor, a critical controlling parameter for organized convection. The derived water vapor flux convergences are analyzed during the recent El Niño episode to map the evolution of the parameter, deep convection, and rainfall over regions impacted by the recent El Niño.

On the Use of Wind Profilers to Study Equatorial Dynamics and Climate

by
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In this paper we present an overview of the use of wind profilers to study contemporary issues in equatorial dynamics and climate. Illustrations will be given from observations at two existing sites: Christmas Island (2°N, 157°W) and Pohnpei (7°W, 158°E). The Pohnpei site has been operated nearly continuously in a vertical only mode since May 1984. Analysis of vertical velocities confirms that mean upward motions in the tropical troposphere are dominated by convection. During clear conditions mean vertical motions are observed to be downward. A few observations of "hot towers" will be shown to illustrate the potential of wind profilers for studying the climatology of tropical convection and scale-interactions with larger-scale tropical dynamical systems. Observations from Christmas Island are available since March 1986 and clearly illustrate the value of wind profilers for continuous monitoring of tropical wind fields. A boundary-layer radar is currently being developed to measure winds below about 2 km. Plans will be presented to incorporate the existing profilers at Christmas Island and Pohnpei to form an equatorial chain extending across the Pacific from Malaysia to Perú.

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SESSION IV

METEOROLOGICAL ASPECTS OF EL NIÑO - SOUTHERN OSCILLATION IN THE SE TROPICAL PACIFIC AND SOUTH AMERICA

La temperatura superficial del mar en aguas ecuatorianas y su relación con El Niño y el clima costero

by
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Observaciones de la Temperatura Superficial del Mar (TSM) han sido realizadas en buques de oportunidad entre el Golfo de Guayaquil y las Islas Galapagos desde 1979 hasta la fecha. Este período incluye uno de los eventos de mayor trascendencia climatológica global, el Fenómeno de El Niño de 1982-83. Se realiza un análisis de la variación temporal de la TSM durante este período y se correlaciona con las medias mensuales del Nivel del Mar (NM) de La Libertad, Temperatura del Aire (TA), Presión Atmosférica (PA) y Precipitación Acumulada (PA) de varias estaciones costeras ecuatorianas.

La variación temporal de la TSM tiene un ciclo anual coincidente con las estaciones seca y húmeda de la región costera, observándose las mayores temperaturas en la época lluviosa y las mínimas temperaturas en la época seca. El debilitamiento del Fenómeno de El Niño 1982-83 es analizado hasta finales de 1985, encontrándose una situación muy anómala durante el último trimestre de este año, con anomalias negativas de TSM considerables para la época. El clima de la región costera depende en gran parte de las condiciones de TSM reinantes en el mar ecuatoriano adyacente. Sin embargo, se han registrado fuertes precipitaciones en forma ocasional, debido quizas a perturbaciones atmosféricas localizadas y al desplazamiento hacia el sur de la Zona de Convergencia Intertropical (ZCIT). Como resultado del análisis de la TSM se esperaba una estación invernal para 1986 de características similares o de menor intensidad que la de 1985. Hasta marzo 1986 se observó una coincidencia sobre esta expectativa. Parece ser que del análisis de la TSM relacionada con parámetros meteorológicos de tipo regional y global, podrían permitir pronosticar un acontecimiento anómalo, tipo Fenómeno de El Niño, al menos en la región costera ecuatoriana.

Ideas about Possible Causal Mechanisms for Heavy Precipitation in Northwest Perú

by
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We are attempting to explain the occurrence of heavy precipitation in the coast, mountain and jungle zones of northern Perú during certain non-

El Niño years (e.g., 1-15 March 1981), by associating them with the same physical mechanisms that govern heavy precipitation in the same zone during El Niño years. This allows us to establish or postulate the occurrence of El Niño-like conditions in any given year, but that are more frequent and more intense during episodes such as 1982-83.

We hypothesize that heavy precipitation in northern Perú is associated with the action of an anticyclone, detected during periods of Amazon rainfall, and its interaction with a thermal low and trough system over Argentina. Along with additional information, the values of the Southern Oscillation Index and an Amazon Pressure Index permit the corroboration of this hypothesis. The Amazon Pressure Index is obtained from stations located in the Amazon regions of Perú and Brasil.

Characteristics of Extreme Rainfall Events in Northern Perú during the 1982-83 El Niño Period

by
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Using daily rainfall data from 59 stations within the Chira-Piura Project of Northern Perú, we have prepared an atlas of histograms and contour maps describing the rainfall characteristics of the region from November 1982 to June 1983. These data often exhibit localized storms of high intensity (> 100 mm/storm) which may then disperse over wider areas of the region during the following 2-3 days. The region surrounding Chulucanas appears to be a focal point for the initiation of such events, particularly during the 1983 months of the study period. Case studies for a few of the most severe events, which occurred in 1983, are presented and compared with an analysis using GOES satellite cloud imagery in conjunction with upper air and surface weather maps, to arrive at a possible scenario for the cause and evolution of such events. The satellite analysis has also permitted us to identify significant storms beyond the range of the ground based stations during this same time period, demonstrating the value of such coverage for developing a more comprehensive view of the processes in effect.

The Evolution of Rainfall in Northern Perú during the Period January 1982 to December 1985, in the Coastal, Mountain and Jungle regions

by
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Northern Perú rainfall - one of the clearest manifestations of the occurrence (or not) of El Niño - is analyzed for the January 1982 to December 1985 period for the three geographic regions of Perú: the coast, the mountains and the jungle. We also present the monthly averages of rainfall in the region of Lake Titicaca for the same period. Although there does not exist an exact correlation between the droughts in this region and excessive rainfall in the northern zone and vice-versa, it would be very interesting to analyze in greater detail the few exceptions that reduce this correlation. We also show the rainfall totals that occurred between January and October of 1986 for all the indicated regions.

Fluctuations of the Semi-permanent Marine Stratocumulus Layer along the Perú Coast between January 1982 and December 1985, Using Data from the Callao Radiosonde

by
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The interannual variability of various parameters that characterize the semi-permanent layer of marine stratocumulus over the coast and offshore waters of Perú can be best described during extreme El Niño events such as 1982-83, its decline and return to normal conditions, and the anti-El Niño conditions observed in 1985. Daily radiosondes take in Callao are used to analyze the evolution of the lowest 1000 meters of the atmosphere between January 1982 and December 1985, in relation to the semi-permanent inversion, which is climatologically ubiquitous along the Perú coast and adjacent ocean. In addition, the long term average seasonal atmospheric profiles (20 years) and water temperatures (27 years) are compared with their values for the Summers and Winters of 1983, 1984 and 1985.

Assessment of 1500 Years of Climate Variability and Potential of Long Term Record of ENSO Events from Andean Glaciers

by
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Some of the glaciers in the Andes contain high resolution records of tropical and subtropical climatic variability over several millennia. In 1983, two ice cores containing 1,350 years (154.8 meters deep) and another containing 1,500 years (163.5 meters deep) were recovered from the Quelccaya ice cap (13°56'S; 70°50'W) in the Andes of southern Perú. The 1,500 year record of climate variability recorded in these two ice cores provide a long-term perspective on climatic variability in the Andes.

Detailed snowpit records from 1975 to 1984 show a substantial decrease (30 percent) in accumulation associated with the 1976-77 and 1982-83 ENSO events. Records from these pits and ice cores over the last century are used to establish a modern analog to characterize ENSO events. Application of the modern analog to the ice core record is used in an attempt to establish a longer term ice core record of ENSO events. The Quelccaya ice cap containing 1,500 years of annually accumulated ice layers may provide a long and detailed record of the most extreme ENSO events. The potential of obtaining long and detailed records of ENSO events from other Andean glaciers is evaluated.

An Alluvial Record of El Niño Events from Northern Coastal Perú

by
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Alluvial sheet flood deposits of northern coastal Perú are unique and provide the potential for the development of a Late Pleistocene chronology of El Niño events.

Alluvial deposits from the 1982-83 ENSO event provide the basis for establishing a type ENSO deposit. Sedimentary structures suggest deposits range from sheet floods to debris flows, however, sheet flood deposits are the most common. Sheet flood deposits are characterized by, a 50-200 cm thick basal gravel, overlain by 10-100 cm thick sand bed, in turn overlain by a >5 cm thick silt bed and capped by a very thin layer of clay. The surface of the deposit commonly displays the original shearflow lines crosscut by post-depositional mudcracks. Human and animal foot-prints are common on the surface of the deposit.

Repeated sheet flood deposits present in the oldest preserved alluvial fill suggest that ENSO type events occurred during the Last Interglacial. Holocene valley fill is almost wholly comprised of these

sheetflood deposits. Locally the upper surfaces of the deposits have been preserved and three prehistoric El Niño events have been recognized and the deposits relatively dated based on the degree of preservation of the surficial features; absolute dates will be obtained from radiocarbon dating of detrital wood samples. Similar deposits present in context with archaeologic sites have the potential for developing a detailed late Holocene chronology of El Niño events. One such event is tentatively dated at 1200 BC on the basis of deposits ponded behind the Cerro Sechin archaeological site in the Rio Sechin Valley.

Observations of El Niño Events at the Chilean Coast (20°S)

by
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This study aims at providing a tentative answer on the development of the El Niño events which took place in the last two decades along the Iquique coast. For the analysis, the events are treated as a characteristic and recurrent association of oceanographic and meteorological variables. For this purpose, monthly averages of the air temperature, sea level air pressure and rainfall amounts from 1970 to 1985, and sea surface temperature from 1976 to 1985 were analyzed. In addition to data obtained by oceanographic cruises in the northern zone of Chile.

Determining the grade of relationship between the variables a correlation analysis and test of hypotheses is made among: sea surface temperature, air temperature and sea level air pressure. Besides, for the time series of monthly averages in each case the graph and correlation coefficient will be included.

Southern Oscillation and River Discharge in Tropical South America

by
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A time series of Southern Oscillation Index (SOI) was constructed using monthly sea-level pressure differences (Tahiti-Darwin). This series was cross-correlated with time series of monthly river discharge deviations from the monthly mean. Both series were standardized by the standard deviation of the appropriate monthly mean. The rivers selected were Trombetas and Jy-Parana, located in the eastern and western sides of the Brazilian Amazon Basin respectively and the Parana River which runs southward from 20°S across Paraguay and Argentina. It was found that the discharge series of both Amazonian rivers were positively correlated and Parana River discharge series negatively correlated with SOI series. The results suggest that SOI series is a potential predictor, at least

qualitatively, of monthly river discharge in Tropical South America especially when the index absolute values are high. Since SOI series goes back to the 1880's, the IOS series might be valuable parameter in statistical regression analyses for reconstructing river discharge time series of short length which most of the time is the only data that hydrologists have to plan and build dams especially in the Amazon.

SESSION V

PHYSICAL OCEANOGRAPHIC ASPECTS OF
EL NINO - SOUTHERN OSCILLATION

Observations of 1982-83 El Niño Thermal and Flow Fields along the Equator in the Eastern Pacific

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The 1982-83 El Niño Southern Oscillation (ENSO) upper ocean thermal and flow fields in the eastern Pacific are described from time series measurements made within the uppermost 250 m at 0°, 95°W and 0°, 110°W. Normal or non El Niño conditions at 110°W were evaluated from measurements recorded from March 1980 - July 1982 and August 1983-September 1985.

The annual cycles of temperature and zonal current at 110°W were most distinctive near the surface: at nominal depths of 15 m and 47.5 m, the average annual amplitudes were 1.5°C and 0.46 m s^{-1}. Monthly mean El Niño currents were defined as the difference between the observations and the annual cycle. During the August - December 1982 onset phase, the strength of the normally westward flowing near-surface South Equatorial Current was greatly reduced to near-zero speed, e.g. at 15 m the El Niño zonal current was eastward at about 0.3 m s^{-1}. The largest vertically averages (15-250 m) zonal current anomalies (0.5 m s^{-1}) occurred in January and February 1983 and represented a substantial decrease in the eastward transport during the termination phase of El Niño.

The surface dynamic height anomaly relative to 400 db along the equator between about 110°W and 150°W was 0.20 dyn m higher in September 1982 than in April, when it is at its annual maximum. At 110°W, the thermocline sank 100 m, reaching its maximum depth in December 1982; temperatures at 100 m and 150 m, which normally are about 15°C and 14°C, reached 27.5°C and 22.5°C; the time rate of change of the 15-200 m heat content was 500 W m^{-2} during the August December 1982 warming phase and -460 W m^{-2} during the January-February 1983 subsurface cooling phase; a surface, eastward jet with a maximum daily speed of 1.75 m s^{-1} at 15 m occurred in May 1983 when the wind direction was eastward; and, the Cromwell Current, normally considered to be a permanent feature of the circulation, disappeared during the subsurface cooling phase. Differences at 95°W (e.g. absence of surface jet, secondary warming, longer disappearance of Cromwell Current- will be described.

Circulation of the Equatorial Undercurrent around the Galapagos Islands

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The Galapagos Islands span the equator from about 1.5N to 1.5S near 91W in the eastern Pacific Ocean. The fate of the eastward flowing Equatorial Undercurrent when it encounters this land mass has long been of interest to equatorial oceanographers. Early measurements suggested a bifurcation of the flow with the main transport occurring north of the equator. On the other hand, analyses of water mass properties suggest that the predominant flow is south of the islands. Recently, three near island surveys have been conducted to study this circulation. These surveys occurred in November 1982, November 1984, and June 1985. All surveys employed underway acoustic Doppler current profiling, CTD's, and XBT's to define the current patterns and the related thermohaline structure. In November 1982 additional velocity data were obtained with the free-fall profiler TOPS. Conditions varied on the three cruises. In November 1982 the Equatorial Undercurrent was anomalously strong (for this season) and deep. Core speed was about 1.0 m/s. This section occurred near the beginning of the 1982-83 El Niño. In November 1984 the Undercurrent was weak (core speed about 0.5 m/s) and in June 1985 the core speed was near 0.7 m/s. On all sections eastward flow was seen north and south of the Galapagos, but the major flow was to the south. The near Galapagos circulation patterns and associated water mass characteristics will be described and compared to the previous measurements.

Propagation and forcing of high frequency sea level variability along the west coast of South America

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Sea level height (SLH) and alongshore wind time series (1980-1984) are analyzed for tide gauges and synoptic weather stations at La Libertad-Salinas (2S) in Ecuador, and Talara-Paita (4S) and Callao (12S) in Perú. To detect the nature of the variability during normal conditions the time series were divided into six month periods for summers (mid-November to mid-May) and winters (mid-May to mid-November), without including the 1982-

1983 El Niño/Southern Oscillation (ENSO) event. The auto- and cross spectra for each season (from 4-5 separate years) are averaged. To detect interannual changes in the variability, analysis is applied to periods prior to, during and following the 1982-83 ENSO event. We analyzed frequency bands in the range from 0.03cpd to 0.5 cpd.

For summer and winter seasons prior to the 1982-83 ENSO, the spectra show very well defined peaks at 14 days, and broad and less energetic peaks at the 9-11 day and 4-7 day bands. During the 1982-83 ENSO there is higher energy over most of the spectrum, the increase being greatest at the lower frequencies. There is a very energetic and well defined peak in the 9-11 day band. Coherence squared between adjacent sea level height stations indicates non-dispersive poleward propagation of events during the 1982-83 ENSO, with phase speeds of 2-4 m/s but no evidence of propagation prior to or after the event. Comparisons (cross-spectra) between coastal SLH and alongshore wind at the same locations show evidence of local forcing at high frequencies (2-6 days). There is no evidence of local forcing at lower frequencies.

Oceanographic Variability off Ecuador Associated with An El Niño Event in 1982-83

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The development of an atypical circulation pattern resulting in an El Niño event off the western coast of South America is described by reference to the oceanographic conditions prevailing off Ecuador during the period 1982-84. The conclusions describe some contrasting conditions during the 1982-83 event with "normal" conditions, as seen in 1981. First signs of the anomaly onset off the Ecuadorian coast were observed in October 1982. Most evident were the increase in sea level, anomalies in the wind field and heavy rainfalls. In February 1983, at the peak of the anomaly, the whole area off Ecuador was covered by very warm (29° - 30°C) and low salinity (less than 33.0 ppt) Tropical Surface Water down to 30-40 m depth. The Equatorial Front, if it existed, was well to the south off Perú. Although the ocean surface was 4°C warmer than normal, the most notable changes took place throughout the water column, a strong depression of the thermocline and all the isotherms down to about 12°C; the largest anomalies being observed over the 100 m water column, up to 9°C at 50 m depth. Thus, the subsurface signal of El Niño was clearly stronger than the surface signal. In addition, the processes normally keeping the surface layer nutrient-rich, such as upwelling, were not evident off Ecuador.

Recovery from the 1982-83 anomaly started in July 1983, showing SST anomalies 2°C colder than during the peak of the event and a general uprising of the isotherms. By October 1983, the presence of the Equatorial Front also attested to the return to normal conditions in the region.

Effects of El Niño on the Eastern Boundary Circulation

by
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El Niño causes dramatic changes in the currents, thermal structure and sea level along the eastern boundary of the south Pacific. Velocity and temperature from moorings along the Peruvian coast from November 1981 to March 1985 are used to describe the effect of El Niño on the circulation.

Each phase of the El Niño affected the strength, steadiness and structure of the Perú Undercurrent in a different manner. Mean alongshore flow is strong and poleward previous to and during the onset of El Niño but becomes weaker and more variable during the mature (second peak) phase. Weak poleward flow occurs after the effects of El Niño diminish. During the El Niño there is significant coherence between alongshore velocity at 5° and 10° South in the 9-10 day band at a lag of about 3 days, yielding a poleward phase speed on the order of 300 km/day. There is no evidence for propagation in this band previous to or after the El Niño. Cross-spectral analysis of local wind, velocity and sea level data is used to identify local and remote forcing of these propagating fluctuations. A comparison of the empirical and dynamic modes is made to illustrate the difference in cross-shelf structure during the El Niño and non-El Niño periods. The results of these analysis are consistent with the wave dynamics expected at the eastern boundary.

On the Mechanism of the Annual and Semiannual SST Fluctuation at the Eastern Equatorial Pacific and its Relationship to El Niño

by
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The purpose of this study is to understand the mechanism responsible for SST and sea level fluctuations at the time scale of months to years, observed at the equatorial eastern Pacific boundary. Spectral analysis of SST indicates statistically significant peaks with semiannual, annual and longer periods. We propose an explanation for the semiannual and annual fluctuations based on the important roles that net local heating, advection of heat associated with remotely forced equatorial waves and upwelling play in the ocean thermodynamics of this region.

The annual cycle of SST is generally consistent in phase and amplitude with the net local heating cycle. However, the larger than

expected SST values observed during the southern hemisphere summer are associated with the semiannual cycle. The semiannual phase structure along the coast indicates that its origin is related to equatorial wave dynamics in the central Pacific. The mechanism of El Niño is examined within this context.

We have also examined the surface wind stress prepared at Florida State University, as well as the model pynocline anomaly variability obtained by Busalacchi and O'Brien, and found that they correlate well with SST anomaly only for very low frequencies, but at high frequencies (semiannual and annual) they are less significant. Upwelling indices are calculated and their relative importance vis-a-vis the remote forcing mechanism is examined for negative SST.

Salinity along the Perú Coast during 1982-1986

by
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As is generally known, the 1982-83 El Niño produced quite remarkable salinity anomalies when compared with previous episodes. As an example, there were unusually high values of 35.2-35.7‰ near the coast of northern Chile and southern Perú that extended northward in April-May 1982-83 to encounter low salinity waters of equatorial origin at about 7°S and 11°S, resulting in a coastal zone along the north-central Perú coast characterized by sharp salinity gradients.

This paper examines the salinity off the Perú coast from cruise data (taken aboard the R/V SNP-1) starting in 1982 and ending in April-May 1986. There will be a detailed description of salinity changes occurring between successive cross-shelf sections taken off Callao, Chimbote and Paita to a maximum depth of 500 m. Greater emphasis is placed on the data taken in the last two years. Also presented are monthly charts of sea surface salinity and its anomalies with respect to the 1929-1977 normals, and shore station data taken from the pier at Chucuito (Callao).

The 1982-1983 "El Niño" off the Northern Coast of Chile, 1981 and 1984 Oceanographic Conditions

by
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Based on temperature, salinity and dissolved oxygen data obtained by 5 oceanographic cruises carried on off the northern coast of Chile, the 1982-83 "El Niño" was studied. Sea surface temperature and mean sea level data registered at the tide gauge stations along the chilean coast, are also considered in this study.

The oceanographic data showed that 1982-83 "El Niño" was observed to begin around September 1982. It reached its maximum February 1983 and ended by September 1983.

The most outstanding physical oceanographic characteristics of the phenomenon were the high surface temperatures and the high surface salinities. In relation with the vertical structure the deepening of the thermocline and the stronger southward intrusion of the equatorial subsurface water mass, characterized the 1982-83 "El Niño".

The mean sea level and the sea surface temperature, showed a significant positive anomaly. This anomaly decreased in intensity toward the south of Chile.

The 1982-1983 El Niño in the Coastal Waters off Guerrero, México

by
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Using hydrographic data from three opportune oceanographic cruises in February 1982, April 1982 and January 1983, and a sea level time series from February 1979 to June 1985 at Acapulco, the 1982-83 El Niño event was detected in the waters over the continental shelf and slope off Guerrero, México. The hydrographic analysis indicates that the local coastal waters (at least to 100 m depth) were displaced to the northwest and offshore by equatorial water masses with an almost vertically uniform thermo-oxy-haline structure that is (on the average) warmer and less saline and has higher concentrations of dissolved oxygen. This can be clearly seen between April 1982 and January 1983, during which time the thermocline and the upper limit of the oxygen minimum layer (=1.0 ml/l) disappeared as a consequence of the displacement. The invasion of equatorial water masses was induced by the propagation of a train of Kelvin waves, generated in the equatorial Pacific, whose phase at maximum amplitude passed by the Guerrero coast at the end of December 1982.

SESSION VI

EFFECTS OF EL NINO ON THE ECOLOGY OF
LOWER TROPHIC LEVELS

Biogenic Particle Fluxes in the Equatorial Pacific: Evidence for both High and Low Productivity El Niño Effects

by
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Biogenic particle fluxes as measured by sediment traps placed near the equator in the Pacific were at least a factor of two lower than normal during the very intense 1982-83 El Niño Southern Oscillation event. Surprisingly, the biogenic particle fluxes measured at a site 11°N of the equator during this same time period were anomalously high. The low particle fluxes at the equator are the expected response of biological productivity to El Niño events. The apparent high productivity at the more northern site seems to reflect an enhanced flow of the North Equatorial Counter Current (NECC). Enhanced NECC flow is associated with a greater doming of the thermocline sufficient to bring nutrient-rich waters into the euphotic zone. The El Niño effects are apparent in the composition of the biogenic particles as well as in the flux of particles. At both sites periods of lower productivity produce particles richer in $CaCo_3$, while high productivity periods are times of high biogenic opal flux.

Cadmium in Corals: Reconstruction of Surface Ocean Fertility at Galapagos

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Cadmium, a trace biologically-mediated constituent of seawater, is distributed analogously to the nutrients PO^4 and NO^3. Because its +2 ionic radius and electron configuration are similar to Ca^{2+}, aragonitic corals record historic dissolved levels of Cd in their skeletal lattice. Under normal circumstances, biological activity depresses surface nutrient and Cd concentrations to uniformly depleted levels. A coral we have analyzed from San Cristobal Island (P. clavus), however, exhibits striking fluctuations in skeletal Cd over the past 35 years. Molar concentrations expressed relative to Ca vary from 1.5 to 6.4 nmol Cd/mol Ca. Based on a distribution coefficient of 1.0, these lattice concentrations translate to dissolved concentrations of 15-64 pM Cd. This range coincides with dissolved Cd measurements encountered along a nearby transect toward Panama, which included areas of upwelling. The Cd record correlates very well with the Southern Oscillation Index and records of SST. This strongly implies that

the cause of the Cd variability is vertical displacement of upwelled source waters which occurs during ENSO events. Thus, at times of normal upwelling, fertile surface waters sustain Cd levels of 40-60 pM. During sever El Niño events, thermocline depression of several tens of meters is sufficient to depress surface Cd concentrations to as little as 15 pM, thus starving the marine ecosystem.

Extended coral Cd records from the Florida Straits and Bermuda depicting quiescent and industrially-perturbed conditions, lend support to the reliability of this lattice-bound tracer. Thus, the potential exists for detailed sub-annual reconstruction of historic and prehistoric ENSO activity.

Effects of El Niño on New, Regenerated and Total Production in Eastern Boundary Upwelling Systems

by
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The impact of El Niño on upwelling ecosystems is expressed at the base of the marine food chain through drastically reduced availability of primary nutrients to the phytoplankton. Reduced availability occurs primarily due to a deepening of the nutricline and reduced flux of nutrient to the surface regions through upwelling. The lower nutrient concentrations in the euphotic zone result in changes in physiological characteristics of the phytoplankton (Wilkerson and Dugdale, this meeting) and in population characteristics such as primary production and standing crops. New production is reduced in direct proportion to the reduction in nutrient flux with a consequent reduction in the flux of biogenic particles from the euphotic zone to the deeper layers of the ocean. Total production, measured as the sum of nitrogen uptake or as carbon uptake, is reduced and the proportion of new to regenerated nitrogen productivity declines to the low values characteristic of oligotrophic regions. Carbon and nitrogen fluxes and pool sizes in the euphotic zone ecosystem are reduced. Changes in nitrogen and carbon productivities are discussed for the El Niño year, 1976 and the non-El Niño year, 1977 at the 15°S upwelling center in Perú. Comparisons are made with conditions observed at Point Conception, California, during the 1982-83 El Niño.

The 1976 El Niño: Biological Response off Ecuador

by
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The moderately strong El Niño event of 1976 had a clearly defined effect on the biological productivity of the eastern equatorial Pacific off

the coast of Ecuador. During March and April 1976, warm (28°C) subtropical surface water of low salinity (33.6 parts per thousand) and low productivity extended from the southwest to the coast of Ecuador and from the equator to 3°S replacing the highly productive water normally associated with the Equatorial Front. The low chlorophyll a (less than 10 mg m^{-2}) concentration, a low primary production (less than 0.2 g C m^{-2} day $^{-1}$) a decrease in diatom cell numbers (18,500 cell m-3), and a low zooplankton biomass, (400 ml 1000 m^{-3}) were associated with the advection of this subtropical water. These values were lower than normal and lower than those in February-March during the El Niño week of 1975. This was specially noticeable in the south of Ecuador and the Gulf of Guayaquil where a value of 1.0 g C m^{-2} day $^{-1}$ was recorded in 1975 compared with 0.1 g C m^{-2} day $^{-1}$ in 1976. Furthermore during El Niño of 1975 values of zooplankton biomass greater than 500 ml 1000 m-3 formed a band extending 180 km west of the Gulf of Guayaquil. During 1976 this band had an extension of only 90 km. North of the equator relatively high primary production, chlorophyll a and zooplankton, dinoflagellates particularly Gymnodinium spp. were predominant which represents a marked perturbation from the normal diatoms predominant population associated with the Equatorial Front. Comparisons are made between El Niño of 1975, El Niño of 1976 and the normal conditions observed during September-October of 1975 when the Equatorial Front was fully developed.

Seasonal and interannual variations in nutrients and phytoplankton along the coast of Perú

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A series of monthly sections along the coast of Perú at 12°S suggest that there is a seasonal variation in the slope of the nutricline and thermocline. During the southern summer the thermocline and nutricline flatten, due to a rise in the offshore (100-300 km) portion of the thermocline and a slight deepening close to shore as a result of weaker upwelling. This summer structure is hypothesized to be of selective advantage to dinoflagellates which form red tides. Time series observations from a station 7 km offshore of Paita, Perú show a progression from diatom dominated communities to dinoflagellate dominated communities from spring to summer. The effects of denitrification and El Niño are discussed around this seasonal model. The timing of spawning of the major commercial fishes in relation to their first feeding is also discussed.

The El Niño Phenomenon and the Resources and Icthyoplankton off Perú

by
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The variability of biotic and abiotic parameters observed during the El Niño occurrences of 1972, 1976 and 1982-83 off Perú are compared with the alterations in the behavior and biological condition of the resources (mainly: anchovy, sardine, jack mackerel and mackerel), reflected in the variations in the distribution and abundance of icthyoplankton. The alternate dominance of planktiferous pelagic species - the sardine increase in 1973-79 and the explosive growth of the anchovy in 1984-86 - suggests a strong influence of environmental conditions during the event, but principally those associated with the post-El Niño recovery phase.

Spatial Distribution of the Macrozoobenthos and Filamentous Bacteria on the Northern Continental Shelf off Perú during and after the 1982-83 El Niño

by
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Biomasses and densities of the different groups of Macrozoobenthos, as well as the biomass of filamentous bacteria, were calculated on the basis of benthic samples obtained at 185 stations from depths of 25-500 m in the area between Zorritos (03°45'S) and Callao (12°00'S) in January 1983 and December 1984. Biological data were correlated with oceanographic and sediment data sampled simultaneously at the same stations. Distribution patterns during and after El Niño of the macrobenthos groups and bacteria are compared with respect to biomass and density.

Densities were generally higher in December 1984 than during El Niño in January 1983, even though oxygen saturation values were similarly low like before El Niño. These results partially sustain observations from shallow Peruvian waters where a favourable post-Niño effect could be detected until May 1984.

Effects of the 1982-83 "El Niño" on the Marine Phytoplankton of the North of Chile

by
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We present the evolution of phytoplankton over a period of five years, based on the analysis of 1243 net and water samples collected on 13 cruises between Arica (18°29'S) and Chanaral (26°20'S) and from the coast to 180 miles offshore. The collection effort took place between December 1980 and August 1985 as part of the ERFEN-CHILE Programme.

During the period prior to the "El Niño" the coastal phytoplankton was dominated by small species of proliferant diatoms that sustain a high biomass with cell densities above 100 cells/ml within 20 miles of the coast, and patches of greater concentration within 10 miles of the coast having values above 1000 cells/ml. Under the anomalous conditions produced by the "El Niño", changes were found in the composition and biomass of phytoplankton evidenced by the noticeable decrease of cell densities to values below 100 cells/ml very close to the coast, the restriction of diatom dominance to a narrow coastal zone three miles wide, and the high frequency of warm water diatoms and dinoflagellates in the coastal plankton. These conditions subsequently reached maximum intensity in June 1983. In December 1983 we encountered the beginning of the return to normality with the dominance of large diatom species near the coast that sustained a biomass slightly above that registered during the "El Niño". In 1985, strongly proliferant small diatoms again dominated along the coast with cell densities similar to the period prior to "El Niño", and the normal distributions of neuritic and oceanic phytoplankton were re-established. Under normal conditions, before and after the event, the presence of red tides caused by the ciliate protozoan Mesodinium rubrum was common.

Should El Niño Conditions Enhance Phytoplankton Production in the Central Gulf of California

by
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Several independent sets of data suggest that phytoplankton production increases within the central Gulf of California during El Niño episodes. This paper examines the hydrographic structure and associated fields of suspended particle concentration to identify physical processes which would favor increased fertilization and productivity in near surface waters during El Niño conditions. This study is based on CTD and beam transmissometer data collected during March, 1983 and March, 1984. The Gulf was dominated by a strong El Niño influence during the Spring of 1983, while a marked decay in the El Niño conditions had occurred by March, 1984. During 1983 the total mass of suspended particulates in near surface water

within the areas of high primary production reached three times that observed in 1984. The region of high particle concentration in 1983 was associated with a well developed coastal jet composed of Gulf water flowing southward along the eastern margin and displacing the warm, low salinity Tropical Surface water which otherwise covered the entire southern and central Gulf. During 1984 the coastal jet was poorly developed and high particle concentrations comparable to 1983 were limited to a much smaller area. These observations suggest that the strong thermohaline contrast between the Tropical Surface water and the Gulf water obtained during an El Niño, may enhance the normal circulation pattern responsible for Spring phytoplankton production in the central Gulf of California.

SESSION VII

EFFECTS OF EL NIÑO ON RECRUITMENT AND FISHERIES PROCESSES

Some preliminary Results from an International Multidisciplinary Project aimed at Reconstructing Monthly Time Series on the Peruvian Ecosystem, for the Year 1953-1982

by
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This paper presents some preliminary results of a project started in 1982 by the Instituto del Mar del Perú (IMARPE), the German Agency for Technical Co-operation (GTZ) and the International Center for Living Aquatic Resources Management (ICLARM) with inputs from the Pacific Fisheries Environmental Group of NMFS, and aimed at reconstructing monthly time series of factors likely to have affected the recruitment and the biomass of the Peruvian anchoveta in the years 1953 to 1982.

Some factors covered are: solar radiation, radiative, evaporative and conductive heat loss, Ekman transport, turbulence, thermocline depth, sea water level, anchoveta catch and catch size, growth rate, biomass, egg production, numbers of birds (3 spp.) and of seals (2 spp.), bonito biomass and their anchoveta consumption. The project origins and aims, and selected time series, are presented and discussed.

Important Changes in the Ecuadorian Pelagic Fisheries since El Niño 1982-1983

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The Ecuadorian pelagic fisheries are characterized by the presence of species such as the sardine, Sardinops sagax; pacific mackerel, Scomber japonicus; round herring, Etrumeus teres and pacific thread herring Opisthonema spp.

In 1971 the total catch amounted 42.000 metric tons and consisted mainly of Opisthonema spp. By 1978, the fleet had grown and yielded 550.000 tons of fish, about 95 % of which was mackerel (S. japonicus) and sardine (S. sagax).

From 1978 the catches maintained a similar composition until "El Niño" 1982-83, when significant changes occurred. First, the pelagic fish

changed their normal distribution, and then disappeared from ecuadorian waters (from Dec. 1982 to Aug. 1983, sardine; and March to Aug. 1983, mackerel), since Sept. 1983 the sardine increased their level in the catches while the mackerel declined. In 1985, the total catches reached an all time record of about 830.000 tons.

Finally, in the first months of 1986, the 1983 year class of sardine has not been observed in Ecuadorian waters, indicating a failure in the spawning during "El Niño" 1982-83.

Interactions between the Populations of Anchovy and Sardine along the Perú Coast from 1970 to the Present. A period of Great Changes

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From 1980 to 1986 important changes in the ecosystem off the Perú coast have been observed, which have been manifested mainly in two phases. The early phase saw the decline in the anchovy population and expansion of the sardine population. The former is attributed to the drastic changes in the environment caused by successive El Niño episodes in 1972-73 and 1976, as well as by the strong stress exerted on the species by fishing effort. The latter is thought to have resulted from the optimal utilization by the sardine of the primary production left by the anchovy. The second phase involved changes associated with the extreme El Niño event of 1982-83, which brought about a return of the anchovy population to levels capable of supporting fisheries exploitation in 1985.

A wide variety of factors are identified that bear on the response capabilities of the anchovy and sardine populations to changes in the physical environment, the various trophic levels and the fishery.

The Effects of the 1982-83 El Niño on the Reproductive Process of the Peruvian Sardine, Sardinops sagax

by
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As a general characteristic, the El Niño phenomenon has great repercussions on the marine ecosystem, seriously affecting exploitable pelagic fish populations. In particular, the reproductive process of adults is altered, with changes in the patterns of spawning.

Under normal conditions along the Perú coast, the reproductive activity of sardines is maximum in the austral winter, conditioned by feeding strategy and a favorable environment. Over a period of several non-warm years, from 1979 through 1981, the reproductive process followed

a normal patter of periodic fluctuations, with a grater gonadal activity during the winter months and a second peak in the summer. With the occurrence of the El Niño in 1982-83 this pattern was altered - primarily in the summer of 1983 - notably affecting the level of gonadal activity and spawning of this species off the coasts of Perú and CHile. In the succeeding years of 1984-85, when the environmental conditions had returned to normal, a similar persistence in the established pattern was observed.

The implications of the alterations of the reproductive process reflect the interaction of the biotic and abiotic factors in the ecosystem that the sardine inhabits.

The Abundance of Sardine and Variation of some Environmental Factors off Baja California, México

by
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The changes in abundance of sardine off the Western Coast of Baja California, as calculated through fishing effort and relative abundance obtained from historic statistics for Magdalena Bay and Cedros Island during the period 1973-1985 were analyzed through their correlation with sea surface temperatures, mean sea level, and upwelling indices.

Correlation test series were made with monthly as well as annual averages, providing for a delayed response by moving averages, and multiple correlation with semiannual averages.

The results show that sardine abundance correlates inversely with sea surface temperature and mean sea level, but does not correlate with upwelling indices for the period considered by this study.

The "El Niño" of 1983 was associated with a low catch for sardine as well as a change in the species composition of the catch.

El Fenómeno El Niño y su Influencia en los Recursos Pelágicos y la Pesquería del Norte de Chile (1983-1986)

by
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Se analizan los efectos de este evento climático oceanográfico sobre los principales recursos pelágicos de la zona norte de Chile (18°21'S-24°00'S), con especial énfasis en los cambios biológico-pesqueros experimentados por las dos especies más importantes del país: la sardina española (Sardinops sagax) y el jurel (Trachurus murphyi).

En forma simultánea se discute la interrelación existente entre las características del medio ambiente, de los recursos y los volumenes de captura; con el propósito de entregar el estado actual y perspectivas de la pesquería cerquera.

Con esta finalidad se describe brevemente la serie histórica de la pesquería, desde 1973 (año en que ésta empieza a cambiar, iniciándose el crecimiento de las capturas de sardina española) hasta 1982, para analizar en detalle las fuertes anomalias observadas en 1983 y sus efectos en la pesquería ejercida hasta junio de 1986.

La investigación biológica-pesquera se basa principalmente en el análisis de las capturas cerqueras, entregándose los resultados de la distribución geografica, composición por tamaño, estructura de edad, crecimiento, aspectos reproductivos y el comportamiento de la abundancia y del reclutamiento a la pesquería, a través de estudios de dinámica poblacional del stock.

Biological effects of the 1982-83 El Niño off Oregon and Washington, U.S.A.

by
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The 1982-83 El Niño was associated with some major biological changes in the ocean off Oregon and Washington, U.S.A. The most dramatic impact was the high mortality and small size of returning adult coho salmon. Purse seining studies during 1979-85 show that juvenile salmon had low abundances and abnormal distributions in 1983. Major shifts occurred in the relative abundance of other pelagic fishes, and Pacific and jack mackerel predominated catches in 1983 and 1984. Rare and unusual fishes from southern waters also appeared in 1983. Abundances of larval fishes were also different. These changes are related to ocean conditions and reduced upwelling of nutrient-rich waters during 1983.

Impact of El Niño 1982-1983 on the Commercially Exploited Invertebrates (Mariscos) of the Peruvian Shore

by
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El Niño (EN) 1982-1983 was stronger than its predecessors and had marked effects on the "mariscos" (shellfish, etc.) of the central Peruvian

coast. These effects occurred during and after EN and both on sandy beaches and rocky shores. They were even visible - although to a lesser degree on deeper sea floors. The environmental changes affected the fauna in various ways: many species suffered mass mortalities (crabs, many mollusks, sea urchins), some responded with a local increase not previously recorded (scallop, octopus, purple snail) or with an extension of their distribution related to the population proliferations (shrimps, rock lobster, swimming crabs, gooseneck barnacles). Some of the effects persisted up to 1986 or were registered only after EN (e.g., immigration of Euphylax dovii and population development of Pollicipes elegans), but as a consequence of the changes during the phenomenon. Generally, the system recovered rapidly, documenting a great resilience, and the total balance was rather favorable for the fishermen although there were clear disadvantages for the people fishing from the shore.

The situation of the shell fish on the central coast of Perú was traced by regular observations during EN and occasional visits afterwards. Landings are studied using the statistics of the landing sites of the port of Pisco (14°S) and all the Peruvian coast.

Changes in Oyster Condition Index with ENSO Events at 46°N in an Eastern Pacific Bay

by
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The amount of oyster meat per shell has been calculated on a monthly basis for the commercially grown Japanese oyster (Crassostrea gigas) in Willapa Bay, Washington, an unpolluted coastal embayment. During the nearly three decades during which consistent measurements have been taken, two major ENSO events (1957-58 and 1982-83) were detected at this latitude, based on increases in sea-level height and sea-surface temperature.

The oyster "Condition Index", a measure of oyster meat quality, is examined in detail here. Decreased values were observed shortly after the 1957-58 event, although a general decline began earlier. Extreme reductions were measured in 1983. This meant that oyster growers in the Bay had to harvest considerably more shells to obtain the same total meat weight as in usual years. At one of our two stations the Index values rebounded to previous levels after the 1982-83 event terminated; at a second station, closer to river runoff, these values began a rise but then dropped precipitously. Interpretation of Conditions Index, and its relation to ENSO events, may require further knowledge of ecological factors.

Modelo de Stock - Reclutamiento de la población de Sardinops sagax, musica (Girard) de la Zona Norte de Chile. Efectos del Niño en la producción anual de huevos y tasas de mortalidad de los pre-reclutas

by
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El problema del reclutamiento en pesquerías pelágicas, sigue siendo el tema central para comprender las fluctuaciones de abundancia que experimentan los clupeoideos.

Se presentan resultados de un modelo estructural de stock-reclutamiento para peces pelágicos, el cual utiliza datos sobre abundancia de la población de sardina española de Chile, entre 1974 y 1985. Se analiza el significado biológico de sus parámetros y el impacto de El Niño (1975-76; y 1982-83), en relación a la producción anual de huevos y tasas de mortalidad de los prerreclutas. Se interpretan las tendencias demográficas con respecto a niveles teóricos de equilibrio.

SESSION VIII

EFFECTS OF EL NINO ON BIRDS AND MAMMALS
AND IMPACTS ON HUMAN ACTIVITIES

Distributional and Demographic Changes in Pinipeds Caused by the El Niño Phenomenon between 21°S and 23°S along the Coast of Chile

by
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Of the pinipeds that inhabit the coasts of the southeast Pacific, only Otaria flavescens had been found in the north of Chile prior to the 1982-83 El Niño episode (Aguayo and Maturana, 1973). In February 1982, months prior to the advent of the El Niño phenomenon (ENP) in the study area, the author discovered a specimen of Arctocephalus australis at latitude 23°05'S (Torres, et.al., 1983; Guerra and Torres, 1983, 1986). During and following the ENP, the density of this species increased and its distribution with respect to O. flavescens was modified.

From 1979 to 1986 the abundance, distribution, reproduction and behavior of O. flavescens were recorded at a sea lion refuge (23°18'S) that harbored an average of 3,500 individuals. Annual censuses were taken of O. flavescens and A. australis from 1983 to 1986 and between 21°S and 23°18'S.

In the present study we analyze the effects of the thermal changes on a typical colony of O. flavescens, the distributional and demographic changes in this species along 200 km of coast, the establishment of A. australis, and aspects relevant to the interaction between the two species.

Photographs, maps and figures are presented for the spatial and temporal analysis of these phenomena.

The Effects of the 1982-83 "El Niño" on the Populations of Humboldt Penguins in Chile

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The Humboldt Penguin, Spheniscus humboldti, is an endemic bird of the Humboldt Current that nests between Punta Aguja (5°47'S) in Perú (Hay, 1983) and Punihuil Island (41°55'S) in Chile (Duffy, 1985). Since more than a century ago, when guano - nesting material for the penguins - began to be exploited intensively, their population has been declining, but never to such low levels as at present. This is primarily because commercial fisheries have competed strongly for their principal sustenance, the

anchoveta (Engraulis ringens) and sardine (Sardinops sagax). On top of this we must add the sporadic occurrence of "El Niño", from which it seems difficult that the birds, already affected by the destruction of their habitat and reduction of their food source, can recover.

From a census carried out by the author between Arica and Valparaiso in 1980-81 (Araya, 1983), the penguin population in Chile was calculated at 10,000 birds, most of them at Pan de Azucar Island (26°09'S), where they numbered about 6,000. In 1984, following the occurrence of the "El Niño", another census was taken at the same sites, to which two previously uncensured colonies were added. At Pan de Azucar Island the population had declined to some 200 birds, a decrease of 96.7 %. Fortunately, the population at Pajaro Niño Islet, previously numbering only 400 birds, has increased to 2,000 in 1985, following the construction in 1981 of a breakwater connecting the islet to the mainland. The effect of the El Niño was most severe in the northern sector of its distribution.

Population Levels of Guano Birds before and after the El Nino Phenomenon of 1982-1983

by
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The three species of guano birds - guaney (Ph. bougainvilli), booby (Sula variegata) and pelican (Pelecanus thagus) - depend mainly on the anchovy (Engraulis ringens) for sustenance. The natural limiting factor on these birds is the oceanographic phenomenon known as "El Niño". But the intervention of man through the industrialization of the anchovy fishery in the decades of the 60'S and 70'S, extracting huge volumes of annual catches, diminished the availability food for guano birds, causing large fluctuations on the populations and considerable changes in the species composition. The 1982-83 El Niño, through its greater intensity and duration, caused a high mortality of guano birds, depressing the populations to nearly critical levels from which they still have not recovered. Data from the graphic censuses of 1985 indicate that the population levels continue to be low.

Fur Seal Foraging Behaviour during El Niño

by
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The South American fur seal (Arctocephalus australis) is a nocturnal predator whose diet consists almost entirely of epi- and meso-pelagic small schooling fish. During El Niño (EN) years, these fish which under normal conditions migrate to the surface at night, limit their movements to deeper waters, becoming less available to the seals. To

examine how these changes in prey availability affect the seals foraging behaviour, Time Depth Recorders were deployed on female fur seals at Pta. San Juan, Perú (15°22'S) in Jan. 1983 during EN (1), in Dec. 1984 (1) and Dec. 1985 (2). In all four records, the animals dove mainly at night making the deepest dives around dusk and dawn and shallower dives throughout the night, following the patterns of vertical migrations of their prey. Mean dive depth in the EN record was significantly deeper (44 m vs. 21, 23 and 29 m). This increase in dive effort was also reflected in changes in the durations of foraging trips: during EN females spent more time at sea foraging (4.5 vs. 3 days). Thus, in years of reduced prey availability female fur seals spend more time and energy foraging. During the 1983 EN, this increase in foraging effort apparently did not increase foraging success: most animals were severely emaciated and a high proportion of the pup and juvenile population starved to death as their mothers were not able to provide enough food.

Feeding of the Bryde Whale during the "El Niño"

by
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This paper analyses the feeding of the Bryde whale, Balaenoptera brydei (Olson) = B. edeni Anderson, in the northern zone of Perú during the El Niño events of 1976 and 1982-83. The year 1976 is considered to have been a weak El Niño, 1981 a normal year and 1982-83 the most intense El Niño of this century. The whale exhibited two feeding modes. In the "oceanic" mode the whale feeds on Vinciguerria lucetia and Sardinops sagax sagax under normal thermal conditions, but on less Viciguerria and more Sardinops during nearly normal and abnormal thermal conditions, in the latter case with a greater variety in stomach contents and a considerable increase of euphausids. In the "neritic" mode, the whale feeds on Sardinopx sagax sagax and Trachurus murphyi under normal thermal conditions, and to a greater extent on Trachurus murphyi under abnormal conditions. Under normal thermal conditions there was a good availability of food, but under abnormal conditions the food supply decreased, with a consequent increase in the percentage of empty stomachs.

The Socio-Economic Effects of the 1982-83 El Niño Phenomenon on the Principal Fisheries of Perú: An Essay on Comprehensive Evaluation

by
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Of the total damage calculated for Perú of the order of 1,544.6 million U.S. Dollars (M$, the estimated effect of the 1982-83 El Niño on the fishing sector alone was 105.9 M$, comprised of 99.5 M$ in cath loss and 6.4 M$ in damages to infrastructure and ships. The official PERU/CEPAL statistics, however, do not reflect the favourable economic value, estimated

at over 50 M$, of benefits to important fisheries such as shrimp (Xiphopenaeus riveti - "camaron titi") and scallop (Argopecten purpuratus) that virtually "exploded" in their levels of abundance, distribution and biomass density, resulting in unheard of increases in activities, catch volume, profits and social benefits, among others.

The aim of this paper is to demonstrate to national planners, to administrators of the fisheries sector and to institutions of scientific and technological research in general (R & D) the importance that the 1982-83 episode had in the fisheries sector and the need to continue the identification, recording, analysis and classification of its effects on the principal activities. I finalize by recommending lines of investigation. The preview of activities, institutional restructuring and the development of technologies, principally for extraction and other concurrent aspects. All of these are necessary in order to procure improved responses to future occurrences of the phenomenon, with projects that optimize the cost benefit-opportunity equation, i.e., minimizing the damages or negative effects while maximizing the benefits.

Documentation of Large-Magnitude El Niño Events using Mollusks from Coastal Archaeological Sites

by
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Elevated SST during the 1982-83 El Niño affected the growth and distribution of bivalve mollusks along coastal Perú and affords a baseline for recognition of prior El Niño events using mollusks obtained from shell middens. Usable criteria include analyses of (1) valve margin profiles, (2) stable isotope ratios along shell profiles, (3) transgressive crossed-lamellar shell microstructure and (4) latitudinal displacement of stenotopic taxa.

Statigraphically controlled and C-14 dated molluscan shell collections are available from numerous South American coastal localities, spanning the last 10,000 years. The modern El Niño phenomenon possibly originates about 5000 years B.P. following the emplacement of the Peruvian Current and concomitant cold-water faunal province. All known pre-5000 year B.P. shell middens north of 9° south latitude contain warm-water (Panamic) faunal associations.

Fossil Evidence for an Early Pleistocene Origin of El Niño off Perú

by
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The 1982-83 El Niño caused the mass mortality of mollusks along the coasts of Perú and Chile, including such archetypes of the Peruvian Province as Aulacomya ater, Gari solida, Mesodesma donacium, and Concholepas concholepas. These and other cold-water mollusks (Choromytilus chorus, Glymeris ovata, Diplodonta inconspicua, Priene scabra, and Crassilabrum crassilabrum) are found, often in great abundance, in Pliocene and early Pleistocene sedimentary deposits of northwestern Perú. Many lived as far north as 4°10'S for at least several hundred thousand years, surviving in the meanwhile a major extinction event in the late Pliocene related to the tectonic destruction of unique coastal habitats. Yet, these same hardy mollusks had retreated southward by 10^2-10^3 km before the late Pleistocene. Their disappearance from equatorial latitudes probably happened for the same reason that the same taxa are now decimated every 10^1-10^2 years at higher latitudes - because 24°-26°C water which characterizes El Niño appeared along the coast. The reproductive success during El Niño of mollusks with tropical ancestry (Argopecten purpuratus, Thais chocolata), known in cool mid-latitude waters of western South America only since the early Pleistocene, may fairly reflect their introduction from the tropics when the El Niño phenomenon was initiated.

POSTER SESSIONS

MODELING AND PREDICTION OF THE COUPLED OCEAN-ATMOSPHERE SYSTEM

A General Circulation Model Investigation of the Atmospheric Response to El Niño

by
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The atmospheric response to sea surface temperature anomalies associated with El Niño episodes is simulated with the use of the NCAR general circulation model. The model features the annual march of both insolation and sea surface temperature.

The model's tropical response is similar to the anomalous features which have been found in previous observational studies. For example, the upper level anticyclone pair in the central Pacific is present for almost all months. An anomalous Walker Circulation is found in the vertical plane along the equatorial region. Rainfall departures from the long-term mean are found elsewhere in the entire equatorial belt.

A Pacific/North American (PNA) pattern is present during the boreal winter, but the anomalous features associated with this pattern are weaker than those simulated by Blckmon et al. (1983) in their perpetual-January experiment, and the features are not all statistically significant. There is indication of a Pacific/South American pattern in the austral winter but the anomalous features associated with it are not all significant. There is large variability in the model's response on a month to month basis. This appears to be a result of the substantial variability in the anomalous forcing.

El Niño and Indian Summer Monsoon Rainfall: Statistical Relationship

by
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The Asian Summer monsoon which is the basic manifestation of the influence of the seasonal heating and cooling over Asiatic land mass constitutes an important element of the global atmospheric and oceanic circulation. The Indian summer monsoon (June to September) gives 70 to 90% of annual rainfall over most parts and is described as the life and soul of the country. The climatic fluctuation like ENSO is most important for

prediction purposes because of its global nature, strong signal, interannual time scale and inherent lag relationships. A detailed statistical examination has been made between the El Niño events and Indian summer monsoon rainfall for the period 1871 to 1980.

During the strong/moderate El Niño events the Indian monsoon rainfall is about 11% below normal and this is statistically (student's t-test) significant at 0.1% level. The Correlation Coefficients (CC) between the two series (1871-1980) is -0.33 which is highly significant. Many scientists have shown that the Sea Surface Temperature (SST- variability at Puerto Chicama, Perú Coast for April/May months represents the El Niño events, the SST rise will be 3°C or more from normal. The detailed examination of Puerto Chicama SST and Indian monsoon rainfall for the period 1925-80 indicates that they are highly correlated (CC for May SST is -0.5) and this information can be used to forecast Indian monsoon rainfall. The regression equation developed for the years 1925-80 is $y = 128.3-2.42x$ where y is Indian monsoon rainfall and x is May SST of Puerto Chicama.

LARGE SCALE METEOROLOGICAL PROCESSES RELATED TO EL NINO - SOUTHERN OSCILLATION

Sea Surface Temperature and Low-level Precipitable Water in the Tropical Pacific

by
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One important parameter that has often been neglected in studies of El Niño-Southern Oscillation (ENSO) events is the lower tropospheric humidity in the tropics. Yet low-level moisture is a crucial link in the supposed connection between warm sea surface temperatures (SST's) and intense convection.

Data from the TIROS-N Operational Vertical Sounder (TOVS) on board the NOAA series of polar orbiting satellites has been used to examine low-level precipitable water (LLPW) in the Pacific. The TOVS instruments give vertical soundings of temperature and moisture on an approximately 6-hourly basis and 250 km horizontal resolution spanning the globe. Earlier studies have demonstrated the suitability of TOVS data for climatological research. We have condensed LLPW data in the 1000-700 mb layer into easily accessible 5° x 5° resolution, daily grids.

Monthly time-latitude diagrams of LLPW in the eastern Pacific and time longitude diagrams in the equatorial Pacific will be shown for the period October 1981-December 1985. Anomalies of LLPW during the 1982-83 ENSO will be computed relative to the four years of the data set. Monthly SST anomalies will be compared with LLPW anomalies to study the presumed link between warm SST's and high humidity. This comparison will shed light on the mechanisms by which above normal SST's can modify the lower troposphere during ENSO events.

Longitudinal Variations in Tropical Tropopause Properties in Relation to Tropical Convection and ENSO Events

by
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This paper focuses on the longitudinal variations in tropopause properties evident in the historical record of tropical Pacific radiosonde data. Over 30 years of radiosonde temperature soundings from tropical Pacific stations (Ponape, Yap, Guam, Majuro, Koror, Kwajalein, Eniwetok, and Truk) have been analyzed to yield tropopause height and tropopause potential temperature show a clear year-to-year variation in response to changes in tropical convection associated with ENSO events. In particular, the tropopause potential temperature appears to be very sensitive to the longitude of major convective activity. As the locus of convective activity

moves eastward during an El Niño there is a concurrent change in the longitudinal gradient of tropopause potential temperature. For example, during an El Niño the tropopause potential temperature is systematically warmer at Koror as compared to Majuro as is clearly illustrated in the 1972-1983 and 1982-1983 ENSO events. This is the reverse of the normal tropopause potential temperature difference between these two stations. Furthermore, the difference in the tropopause potential temperature between these two stations forms an ENSO index with interannual variations well correlated with the conventional ENSO index formed by the Tahiti-Darwin Surface pressure.

METEOROLOGICAL ASPECTS OF EL NINO - SOUTHERN OSCILLATION IN THE SE TROPICAL PACIFIC AND SOUTH AMERICA

Cold Front Disturbances: A Way of Monitoring the "El Niño" Phenomenon

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A way of monitoring "El Niño" on a synoptic scale is proposed by following the cold front disturbances that arrive at the Peruvian jungle, because these disturbances depend on the South Pacific anticyclone for their progression on the eastern side of the Andes ridges.

Synoptic surface meteorologic information recorded along the Peruvian mountain-ridge and jungle from June to September since 1980 is analyzed. From the results obtained, one can say that in 1982 a very different behaviour from other years was recorded, and very different spatial-temporal patterns of precipitation were recorded in the mountains and jungle of Perú during the invasion of cold fronts. In this was a synoptic scale signal of the anomalous behaviour of the atmospheric circulation associated with the 82-83 "El Niño" has been found. Results of transverse sections of zonal winds along the Peruvian-Chilean coast will also be shown for the same period.

Analysis of the Fields of Temperature and Winds Offshore of and Along the West Coast of South America

by
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The coast and sea of Perú is particularly sensitive to extreme events such as El Niño and its antithesis. This study involves a spatial and temporal analysis of the fields of air and water temperature and winds since the 1982-1983 El Niño until July 1986, with data from research and merchant vessels, islands and coastal stations. We also include data from 1972 to the present, for which we compare various periods in which there occurred El Niño and anti-Niño events. We also call attention to the behaviour of the atmosphere from Callao to 200 miles offshore.

Analysis of a Meridional Vertical Section of the Atmosphere along the West Coat of South America

by
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The El Niño phenomenon that influences the west coast of South America is a regional response to changes in the atmospheric circulation on a global scale. The study of the phenomenon leads us to evaluate the position and intensity of the zonal and meridional circulation in a meridional section using monthly averaged soundings for 1980 to 1985 at established radiosonde stations along the west coast of South America: Callao (Perú), Antofagasta, Quintero, Puerto Montt and Punta Arenas (Chile). Finally, considering the work of Berlage (1966), who suggested that a weakening of the Perú Current is associated with the low phase of the Southern Oscillation (lower pressures in the southeast Pacific, higher pressures over Indonesia), we will show how these anomalies are manifested by a deceleration of the general circulation of the ocean and atmosphere in the southern region of the Pacific Ocean. As a consequence, the Perú Current is weakened and the relatively warm water of the South Equatorial Countercurrent invade the Perú coast.

Precipitation Mechanisms in the Peruvian Territory during the 1982-83 "El Niño" Phenomenon and and in the Subsequent Rainy Periods

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From the analysis of the satellite and RWS information as well as the precipitation data in the Peruvian territory, it is inferred that there are basic and typical configurations that show persistent regional patterns dictated by topographic contours.

In this paper we try to associate the circulation patterns and the role that the cordillera plays under two different topographic conditions, during the 1982-83 El Niño Phenomenon and during the 1984-85 and 1985-86 rainy periods. It seems that the interaction between the Subtropical Jet and Andes Cordillera plays an important role in the Teleconnections associated with El Niño.

Cross Spectral Analysis of Data from Northern Perú

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In this study we are trying to determine the phase relationships between analogous meteorological variables at two geographical points in an area subject to the same influences. The study is based on the calculation of the correlation function between two random functions, making use of the fast Fourier transform (FFT). In the main, we are correlating the points Tahiti-Darwin and Talara+Chiclayo with pressures and sea surface temperatures. It is hoped that a certain phase will result, with Talara+Chiclayo lagging, and thus know beforehand that the El Niño phenomenon is imminent.

Conjetura sobre Sincronía en algunos de los Movimientos Planetarios que causan Variaciones en el Clima Mundial

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Además de los movimientos fundamentales de nuestro planeta tierra, existen otros que obedecen a influencias muy variadas originadas en el mismo planeta o en interacciones con los demás cuerpos del sistema solar. Estos movimientos de precesión del eje de rotación de la tierra tienen períodos, magnitudes y comportamientos muy variados. Al representar estos movimientos dentro de un modelo geométrico se pueden encontrar sincronizaciones y sumatorias significativas que afectan la declinación solar cambiando la insolación incidente en los hemisferios.

Si al cuestionar la Teoría Milankovitch sobre glaciaciones se acepta este modelo geométrico, obtenemos una alternativa aclaratoria sobre las variaciones del clima que producen las modificaciones en el comportamiento de las grandes corrientes oceánicas y por ende el Fenómeno "El Niño".

Hidrología del Fenómeno El Niño en el Perú

by
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Determinar un plan de acción y una base metodológica preliminar (común), que permita evaluar y determinar las repercusiones hidrológicas del fenómeno en el Perú, tendientes a prevenir y minimizar sus efectos negativos principalmente, así como iniciar una investigación hidrológica en el continente sobre el fenómeno "El Niño".

El fenómeno meteorológico "El Niño", tiene sus consecuencias de mayor influencia en el ámbito marino causando variaciones muy significativas en su ecología e hidrológica en el continente en sus cuencas, mediante eventos extremos como inundaciones y sequías, así como en otras áreas aún desconocidas.

Al respecto, los países de la región aisladamente han venido evaluando sus consecuencias sin patrones hidrológicos comunes que permitan conocer las características del fenómeno a nivel macro.

La noticia o aviso sobre la ocurrencia de un fenómeno "El Niño", sería poco útil si no es complementada con información de estudios que precisan sus consecuencias y su variabilidad e intensidad en el espacio y en el tiempo.

El logro de este objetivo está condicionado por la ausencia de evaluaciones hidrológicas del fenómeno a través de su historia.

El SENHAMI, y su Dirección de Hidrología ha avanzado al respecto y evaluado en su zona continental los parámetros, como temperatura, precipitación y escorrentía superficial (Zonas Noroeste y Sudeste). Para tal fin analizó cerca de doscientas (200) estaciones hidrológicas e hidrometeorológicas, logrando caracterizar y comparar los cuatro últimos "niños" como son: 64-65, 71-72, 72-73 y 82-83, mediante el análisis de valores horarios, mensuales y anuales de c/u de ellos.

El estudio ha permitido entre otros aspectos, definir su área de influencia, zonas afectadas, intensidad, etc. así como la sensibilidad de los parámetros hidrológicos frente al evento. Igualmente consideramos que la red de estaciones vinculadas a la vigilancia meteorológica y la red climatológica, encontrarán en la red hidrológica e hidrometeorológica un apoyo significativo que complemente la información sobre el fenómeno, dado al aspecto hidrológico en las cuencas y en especial en cuencas que sólo poseen información hidrométrica, las cuales destacan por su función integradora.

Finalmente consideramos que el Estudio Hidrológico Regional del Fenómeno "El Niño", ensamblará fuertemente el aspecto Meteorológico (CAUSA) e Hidrológico (EFECTO) del evento.

PHYSICAL OCEANOGRAPHIC ASPECTS OF EL NINO - SOUTHERN OSCILLATION

Comparison of Inverted Echo Sounder and Hydrographic Data in the Galapagos Islands Region during the 1982-83 El Niño

by
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Inverted echo sounders (IES) were successfully deployed in the eastern equatorial Pacific along 85°W and 95°W from November to May 1984.

The IES measures round-trip acoustic travel time from the sea floor to the sea surface, and because the speed of sound depends on density, travel time generally correlates well with dynamic height anomaly. The IES deployment coincided with the 1982-83 El Niño and so provided an opportunity to study the dynamic height field of the region during this event.

This data is correlated with the results of a set of CTD and XBT casts in order to establish the usefulness and proper interpretation of IES measurements in the equatorial Pacific.

Bravezas de Mar along the Perú Coast in relation to El Niño

by
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A term as frequent and typical as "El Niño Current" is "bravezas del mar" (storm surf), both terms being used by our fishing ancestors and described as well by Humboldt. We have quantified the occurrence and duration of the "bravezas" phenomenon along our coast on the basis of analog water level information at ports from 1955 to 1986. From this we extract ac comparative analysis for the "bravezas" of duration, arrival time, source, swell period, etc. It is noteworthy that in normal years the occurrence of "bravezas" is more frequent from May to September, with two to four days duration in the month of occurrence. On the other hand, in "El Niño" years these "bravezas" also occur in December or the months of January to March. In 1972 and 1983 there were "bravezas" throughout the year, occurring with greater frequency and with durations of six to eight days.

Daily Upwelling and Turbulence Indices off the Peruvian Coast at Callao and Trujillo during the period 1953-1983

by
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Daily upwelling and turbulence indices have been calculated for the period 1953-1983 using hourly wind data registered by CORPAC (Peruvian Civil Aviation Corporation) at their stations in Callao (12°00'S) and Trujillo (08°06'S). The coastal upwelling index is based on the offshore

kman surface wind transport (Bakun, 1975). The turbulence indices are assumed to be proportional to the cube of the wind intensity as in Muller and Kraus (1977).

The monthly variations during normal years and the effect of the El Niño phenomenon on the offshore Ekman transport are discussed.

Anomalies of Coastal Temperature and Sea Level along the Chilean Coast during the Last Three Decades

by
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Coastal sea surface temperature (SST) and sea level from six tide stations between 18°S and 42°S are discussed. The time series covers at least 30 to 40 years.

There are periods characterized by low SST and low sea level (1954-56, 1970-71, 1973-74). These periods usually occur just before an El Niño event. On the other hand, high temperatures and positive anomalies of sea level occur during El Niño events (1957-58, 1972, 1976, 1982-83).

Both types of signals occur almost simultaneously and are clearly evident along the coast, up to Puerto Montt (42°S).

The Decline of the 1982-83 "El Niño" along the Coast of Perú

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Just as important as the process of generation and evolution of an event such as "El Niño" is the recovery of the ocean and its return to normal climatic conditions, since this represents the reactive capability of the system to an anomaly of prolonged duration. The El Niño of 1982-83 was one of the most intense ever recorded, and the recovery process in the coastal waters off Perú is illustrative when it is compared with other, similar events that have occurred previously. In this paper I will present an analysis of sea level data, the variability of the thermal structure, and the sea surface temperature at some of the coastal stations following the 1982-83 El Niño and other similar events in the past.

The Annual and Semiannual Cycles in Perú Coast SST, and their Year-to-year Variability

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The annual and semiannual cycle in SST at Peruvian coastal stations is documented. It is shown that the semiannual cycle is comparable to that of the annual cycle. The semiannual cycle is significantly correlated with the semiannual cycle in the central equatorial Pacific zonal wind 2 months before, but the relationship explains only a small part of the variance. The amplitude of the semiannual cycle in SST, and in general of periods from 2 to 15 months, is enhanced during the ENSO warm events of the last 3 decades.

Meteorological and Physical Oceanography Aspects of El Niño on the Mexican Pacific Coasts

by
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We have characterized the El Niño event on the Mexican Pacific Coasts. The El Niño event of 1982-83 started in July 1982 whereas earlier events started in March. The general picture of the warming episodes is a bi-phasic curve (MSL and SST). The 1982-83 El Niño has its first maximum between October and December then it falls in January and February; the second maximum is found during March to May, in contrast to earlier events which peak first in May-July, drop in August-September with a second largest maximum which lasts from October until January. The second Peak of the 1982-83 El Niño event resembles the second peak of earlier events. The results show that El Niño produces positive anomalies of the air temperature and cloudiness (sunshine below normal). Our results in SST are quite similar to those found for La Libertad (Ecuador) and Talara and Callao (Perú) as reported by Enfield (1984) and the composites of SST anomalies are quite similar to those - shown by Rasmusson and Carpenter (1982) for Puerto Chicama. The simultaneous occurrence of air temperature, sea surface temperature and mean sea level anomalies is an indication that the atmospheric warming may be correlated with the presence of warm waters carried toward the Mexican Pacific Coasts by the corresponding branch of the Equatorial Countercurrent.

An Optimum XBT Sampling Network for the Eastern Pacific Ocean

by
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An objective analysis technique, developed by Gandin (1963), is used to design an optimum oceanographic network for the eastern Pacific Ocean from 160°W-60°W, 20°S-20°N. XBT observations from the SURTROPAC data set (1979-1984) were employed to estimate correlation statistics for variables sea surface temperature, depth of 25°, 20° and 15° isotherms and the heat content for the top 200 and 400 metres, representing thermal structure of both the surface and subsurface layers.

Methodology of optimum interpolation is based on a standard result of statistical estimation theory - the Gauss Markov Theorem - and provides the best, least square linear estimate of some field, in this case temperature. The method is particularly useful in an oceanographic context

as it enables the design of an observational programme required to map the temperature field with a pre-specified level of accuracy. After data have been collected it allows for the optimum gridding of data which are irregularly distributed in time and space. Statistical information of long term mean, and the spatial and temporal correlation structure determine a measure for the intensity of the signal variability compared to that of unresolved geophysical noise. The statistics then lead to detection of ocean thermal variability, thus determining the dominant time and space scales. Selection of the sampling density is dependent on the size of the interpolation error associated with these scales, which can be tolerated. For the eastern Pacific, the thermal statistical temporal and spatial signals fluctuate according to the presence and strength of El Niño. Thus the proposed minimum sampling density for the optimum oceanographic network of the region must account for this interannual variability.

Sea Level and Current Variability in the 5 Day Frequency Band at the Galapagos Islands, 1981-83

by
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Near surface pressure sensors at the Galapagos Islands and current measurements at 0°N 95°W were used to investigate the time variability and spatial structure of the 5 day frequency band. The gauges were deployed at Calita Iguana (0°59'S, 91°30'W) and Vincente Roca (0°3'S, 91°28'W) on Isabela Island, at (1°24'N, 91°50'W) on Wenman (Wolf) Island and at Bahia Hobbs (0°42'S, 89°18'W) on San Cristobal Island. The current measurements were taken at 15, 50, 75, 100, 150, 200 and 250 meters depth. The pressure and current measurements were collected from July 1979 to January 1985 and July 1981 to November 1983, respectively. A time period common to both data sets include the year (July 1981 to July 1982) preceding, the year (July 1982 to July 1983) during, and a half year period (July 1983 to November 1983) following the 1982-83 El Niño event. The analysis concentrates on the time variability of the 5 day frequency band. Empirical orthogonal function analysis gives evidence for the existence of equatorially trapped waves at a 5 day period. The variance of sea level in the 5 day frequency band is found to be substantially affected by the El Niño event.

Baroclinic transports and their associated events off the Pacific Coast of Canada during the 1982-83 El Niño

by
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The largest anomaly of Baroclinic transport off the Pacific coast of Canada occurred in March 1983 during the 1982-83 ENSO. It was centered at a location some few hundred kilometers offshore of the shelf break. The poleward surface velocity was 10 cm s^{-1} in excess of the climatological March average velocity. Associated with this relatively high-velocity water was a core of temperature anomaly of 3°C in the subsurface layers.

Elsewhere, several hundred kilometers north an intense anticyclonic, baroclinic eddy developed in the autumn of 1982 and grew to its maximum intensity in the spring of 1983. It persisted to at least the summer of 1983. Such a large eddy, with transport (relative to 1000 db level) of $10^6 \times 10$ $m^3 s^{-1}$, has never been observed off this coast.

Variations of Subsurface Flows in the Eastern Pacific Transect from Costa Rica to Coco Island

by
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We present some features of subsurface flows along a section between Cabo Blanco (9°23'N, 87°11'W) and Coco Island (5°33'N, 87°11'W), associated with Thermal structure. The observations were made during 1983-1984. The estimation of the geostrophic flow field was derived from a density field, which has been modeled from temperature data (XBT), using T-S curve-fitted relations between salinity and temperature in this region. Heat and mass transports were estimated.

Observations on the Presence of the 1982-83 El Niño in Herradura Bay, Coquimbo

by
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From 1977 to the present, continuous and discrete recordings have been made at the pier of Herradura Bay (29°58'30"S; 71°22'30"W) of several oceanic and meteorological variables, including surface temperature, winds and solar radiation. Moreover, hydrographic stations have been made in the interior of the bay and adjacent zone, including 13 stations between October 1982 and June 1983.

From the analysis of daily fluctuations of the surface temperatures at the pier (observed at 09.00 local hours), it is found that they are not affected by local conditions, such as solar radiation, winds and tides, but that they respond instead to variations in the open ocean. The monthly anomalies show warming between September 1982 and August 1983, and reach a maximum of 2.2°C in January 1983.

The study of the thermal variations at 0, 20 and 50 m at the hydrographic stations show large anomalies in the 13 stations sampled during El Niño, when compared with an average annual cycle for this location. It is possible to detect a depression of the thermocline at the mouth of the bay from October 20 to December 14, 1982, and a thermal decrease that does not affect the surface; however, this decrease of 1.5°C propagates toward the surface in the center of the bay and at the pier.

Perú Coastal Upwelling Regimes near 5°S and 10°S during normal and El Niño Times: 1981-1984

by
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During recent years (1981-84), the coastal upwelling region adjacent to the Perú coast between 5°S and 12°S has been intensively studied. The regime at 5°S and 12°S is of particular interest because it is at very low latitude compared to other coastal upwelling regions studied: the baroclinic radius of deformation is of order 100 km, much greater than the local shelf width and three time wider than at 15°S where the Coastal Upwelling Ecosystem Analysis experiments were conducted. The timing of the recent intensive observations at 5°S and 10°S is also of particular interest: a series of CTD sections, continental shelf current meter moorings, and oceanographic and meteorological shore station observations began in 1981 and 1982 before El Niño and were continued until mid-1984.

In this paper we discuss both the event scale variability and the El Niño perturbations. Moorings on the continental shelf and/or slope record subsurface temperature and current velocity near 50 and 100 m depth from November 1981 to May 1984. The two El Niño pulses, the initial rise beginning in late September 1982 and the second, higher pulse beginning in late March 1983, are recorded. The temperature at 50 m, normally within the range 14-18 C rose to a maximum of 29 C at 5°S in May 1983 before plummeting to 17 C in July 1983. Comparison of the CTD sections with the wind, current and temperature time series show that coastal upwelling at 5°S collapsed only during the second El Niño pulse when local winds were very weak. A CTD section at 10°S in May 1983 suggests that coastal upwelling ceased there in spite of locally favourable winds, perhaps because the alongshore pressure gradient induced an on-shore geostrophic flow larger than the offshore Ekman transport.

Subsurface Temperature Patterns in the Eastern Equatorial Pacific during the El Niño Event of 1982-83

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More than four thousand CTD and XBT profiles were collected from the eastern tropical Pacific Ocean during the El Niño event of 1982-83. The patterns associated with the El Niño event are described as the departures from the patterns observed during the EASTROPAC cruises of 1967-68. Isotherm displacement patterns are suggestive of wave-dynamical effects during the early stages of the El Niño, but subsequently become less distinct, suggesting a mixture of local and remote effects.

Coastal Currents along the West Coasts of the Americas during El Niño

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Theory suggests that the currents along the Pacific Ocean's eastern boundary would become more poleward at the onset of El Niño. Observations of the currents made from subsurface moorings on the continental shelves of both Perú (5°S and 10°S) and Oregon (43°N) during 1981-84 show that the currents became more strongly poleward in October 1982. There was a very rapid poleward acceleration of the flow at 5°S and 10°S, coincident with the rise in sea level and the beginning of the anomalous warming. That this is a typical response of coastal currents off Perú to El Niño is corroborated by similar measurements made at 15°S during 1976-77. Probably only a very strong El Niño, as in 1982-83, has a noticeable effect on mid-latitude currents: observations of currents made at 45°N during 1972 do not appear to be anomalously poleward, but those made at 43°N in late 1982 are.

This paper presents the time-series of subsurface temperature and currents from the Perú shelf during 1976-77 and 1981-85 and from the Oregon shelf during 1972-74 and 1981-84. The relationships between the subsurface current and temperature and the sea level and local winds at the respective sites are discussed. The similarities and the differences between the low and high latitude response of coastal currents to El Niño are emphasized.

On the source of 9-11 day propagating signals in coastal sea level off South America during the 1982-83 El Niño

by
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Following the work of Cornejo and Enfield (related conference paper), it is shown that a strong 9-11 day signal was present in the 1-2 week band of sea level height (SLH) spectra along the South American coast during most of the 1982-83 El Niño episode. This signal was much weaker or non-existent before and after the El Niño. The fluctuations propagate poleward along the Ecuador-Perú coast and do not appear to be related to local winds. Based on the hypothesis that the signal represents coastal trapped waves resulting from equatorial waves incident on the eastern boundary, we are investigating their relationship to SLH at equatorial islands and to a two dimensional array of subsurface pressure (SSP) sensors and inverted echo sounders (IES) that were deployed in November 1982 for one year, in the region between 3N-3S and 85-95W.

Coherence and phase spectra between the coastal SLH variability and SLH at Santa Cruz Island (near the equator, Galapagos) give only weak and scattered indications of coherent propagation, consistent with equatorial Kelvin waves. However, meridionally anti-symetric structures exist in the data from the cross-equatorial array of SSP and IES gauges that may explain a significant portion of the coastal signal as being due to the arrival of energy in the form of Rossby-gravity (Yanai) waves of very low wave number. We will discuss these structures and their relation to coastal SLH, and attempt to say something about where and how they might be forced and - if connected - why the coastal signal is so characteristic of the El Niño period.

Variación del nivel medio del mar en Ecuador

by
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Se recopiló toda la información existente en las estaciones mareográficas de Esmeraldas, Bahía de Caráquez, Manta y puerto Bolivar, para calcular el nivel medio de cada una de ellas y, luego se comparó con el nivel medio del mar de la Libertad mediante nivelaciones geométricas.

Se analizó las desviaciones del nivel del mar de La Libertad desde el año 1948 hasta 1985, especialmente en los eventos de "El Niño" ocurridos en ese período.

Influencia del fenómeno "El Niño" sobre las Condiciones Termo-Salinas en Aguas Costeras Ecuatorianas

by
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Usando datos de observaciones realizadas, se analizan los cambios de temperatura y salinidad superficial en las aguas costeras ecuatorianas, un año previo y dos años después de haberse producido el evento El Niño 1982-83, para de esta manera evaluar la extensión y magnitud que ha tenido el fenómeno sobre la citada zona costera.

Las variaciones mensuales de temperatura y salinidad en las estaciones costeras continentales (Esmeraldas, Manta, Salinas y Pto. Bolivar) durante los años 1981-84-85 son comparados con los del Evento 1982-83.

Al analizar el comportamiento térmico y salino se observa que en el área norte (Esmeraldas) y Sur (Pto. Bolivar) se presenta normal para los años 1981-84-85, mientras que para los años El Niño 1982-83 estas condiciones se transforman, incrementándose el parámetro térmico y disminuyendo el parámetro salino, lo cual es congruente con la aparición del evento El Niño.

EFFECTS OF EL NINO ON THE ECOLOGY OF LOWER TROPHIC LEVELS

Effects of "El Niño" event on the zooplankton and icthyoplankton of Ecuadorian coastal water, 1983-84-85

by
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Seasonal variations, and year to year fluctuations in zooplankton volumes, eggs and larvae of Sardine, Sardinops sagax, round herring, Etrumeus teres, and mackerel Scomber japonicus were observed in Ecuadorian coastal waters, during several cruises carried out in 1983, 1984 and 1985.

In the first semester of 1983, it was found a reduction of zooplankton volume, a low number of eggs and larvae of round herring and mackerel, and an absence of sardine. All these findings, were probably caused by "El Niño" event. In the last part of 1983, during the months of September and October, the volumes of the zooplankton and numbers of eggs and larvae started to increase. In the cruises carried out in 1984 and 1985, after "El Niño" anomaly, the numbers of eggs and larvae were the highest, but without reaching the maximum values found in the year of 1981.

Primary Productivity in the Gulf of California during 1982-1985

by
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The response of the phytoplankton populations of the Gulf of California to the past El Niño event has been studied since March of 1983. The results of six oceanographic cruises during the period 1983-1985 are reported on here. The maximum values of phytoplankton biomass and productivity were reached in March 1983, with averages of 70 mg/m2 and 3.0 gC/m2/day for chlorophyll a concentration and productivity, respectively. The minimum values were found in November-December 1984, with averages of 22 mg/m2 and 0.26 gC/m2/day, respectively. These results show that the ecosystem of the Gulf was enriched at the peak of El Niño, with gradually decaying production until normal levels were reached in mid-1984. The implications of this pattern for the regional fisheries are discussed.

Satellite Observations of Phytoplankton Variability during El Niño

by
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Satellite ocean color data are used to quantify the large-scale variability in phytoplankton distribution and abundances in the eastern equatorial Pacific. It is shown that one can use satellite ocean color data to define and monitor the region of enhanced biological production associated with the coastal upwelling system. Significant interannual variability in the areal extent of this region is shown to exist under non-perturbed (i.e., non-El Niño) conditions. Basing estimates of total ecosystem production on the physical description of the upwelling zone rather than on the area defined by enhanced levels of biological production can lead to significant errors. Using some rather basic assumptions and the quantitative information contained in the ocean color data, it is demonstrated how the increased spatial coverage offered by satellites may significantly reduce the errors associated with regional primary production estimates. The impact of the 1982-83 El Niño on phytoplankton distribution and abundance is also described.

Modification of Copepod Populations in relation to Physical Properties during the 1982-83 El Niño

by
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Owing to the zooplankton sampling and to surface (T,S) and subsurface (XBT) observations gathered along the merchant ships tracks Panama-Tahiti and Panama-Mururoa (French Polynesia) of the SURTROPAC monitoring system, it has been possible to follow the response of epiplanktonic copepod populations to the 1982-83 El Niño in the eastern equatorial Pacific. In the equatorial area, one notices the quasi-disappearance of the main species whose abundance variations are connected to the seasonal fluctuations of the upwelling. The southward extension of low-salinity surface water from the Gulf of Panama is related to a new geographical distribution of some species usually located north of the Galapagos thermohaline front. After the warm event, in 1984, the abundance of most of the species has increased but in a very non uniform fashion and often without the usual connection with the seasonal cycle.

A BASIC Computer Programme for the Classification of Phytoplankton in relation to the El Niño Phenomenon in Colombia

by
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The purpose of this investigation is to compare current oceanographic information on dinoflagelate phytoplankton from the Pacific coast of Colombia with the results that other countries have obtained in the Regional Study of the "El Niño" Phenomenon (ERFEN) off South America. As in Ecuador, Perú and Chile, we have found indicator species off our coast that are characteristic of the anomalous conditions and their effects on the primary productivity and lower trophic level.

The species information has been compiled using a BASIC computer programme for the analysis of community ecological data, which is described. The programme estimates the Shannon diversity index, descriptive statistics, the maximum and minimum ranks according to the salinities and temperatures where species were found, and, finally, the taxonomic levels from species to phylum.

The information used is from the "pre-Niño" period of November-December 1979 and the "El Niño" episode of November-December 1982, based on oceanographic cruises carried out in those years.

Nutrient Distributions in the Shelf Waters off Guerrero, México, during the 1982-83 ENSO episode

by
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The 1982-83 ENSO has been so far the most intense, long and geographically extended warm episode of the present century. Its impact was detected along the eastern Pacific at latitudes as high as 50°N and 48°S this paper reports such event as observed in the shelf waters off Guerrero, México (16°N-18°N). Local impact is interpreted under the light of observed fluctuation in the distributions of nutrient concentrations. Difference in the consumption-production rates between these nutrients, makes some of them more appropriate to describe the local effects of the 1982-83 ENSO. Therefore, conclusions are based mainly in the silicate and the orthophosphate distributions. Results indicate that the 1982-83 ENSO locally revealed as the relatively nutrient depleted invasion of surface waters from lower latitudes which displaced the local waters northward and away from the coast, lowering the biochemical potential at the shelf region.

The 1983-84 "El Niño" Effects on Nutrients and Summer Phytoplankton of a Baja California Upwelling Zone

by
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We generated time series of T°C, S°/oo, O_2, nutrients (NO_2, NO_3, PO_4 and SiO_2), chlorophyll a and phaeopigments, phytoplankton abundance by major taxa (diatoms, dinoflagellates and others) and photosynthetic parameters (assimilation number and initial slope at low irradiance) for the surface waters of a coastal location off Northwestern Baja California (30°20'N, 115°58'W), during the summers of 1983 and 1984. We sampled every day during 18 days in 1983 and during 20 days in 1984. Comparing these data with those from the "normal" years of 1977 and 1979 (previous works), we found that T°C and nannoplankton abundance were higher during the summers of "El Niño" 1983-1984 years, and nutrients, chlorophyll a, diatom and dinoflagellate abundance, and assimilation numbers, were lower that those for the summers of 1977 and 1979. Chlorophyll a values were as high as 15-16 $mg.m^{-3}$ in 1977 and 1979; and they were only up to 2 $mg.m^3$ in 1983-84. Highest assimilation numbers were > 13 mgC. (mg Chl a)$^{-1}$.h^{-1} in 1977 and 1979; and they were only up to 5 in 1983-84.

Abundance and Distribution of Water Mass Indicator Dinoflagellates along the Perú Coast during the El Niño Phenomenon of 1982-83

by
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The monitoring of the quantitative distribution of dinoflagellates during and after the 1982-83 El Niño made it possible to follow the evolution of the event. Certain species were selected as indicators of the different water masses of the Perú coast. The abundance and frequency of these species, as well as the expansion and reduction of their area of distribution describes the movement of the water masses, showing the development of the phenomenon from its beginning, its evolution and its disappearance or return to normality. The material from the cruises conducted from September 1982 to February 1985 is analyzed.

The Presence of Red Tides in the Central Zone of Chile Associated with the 1982-83 "El Niño" Phenomenon

by
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In March 1983 a red tide phenomenon was observed between the bays of Valparaiso (33°01'S) and Quintero (32°45'S), caused by the dinoflagellates Prorocentrum micans Ehrenberg and Prorocentrum gracile Schutt, which reached concentrations of 1900 and 2150 cells/ml, respectively. Both taxa remained together in the plankton most of the time, with P. micans eventually dominating absolutely. In March 1985, new discolorations of the sea water were detected in Valparaiso Bay, associated with P. gracile. The maximum concentration observed was 17,000 cells/ml. Morphological comparisons were made between samples from both collections. Taxonomic similarities and differences vis-a-vis P. micans were established using a photon and electron sweep microscope. It is worth noting that the latter species has been the cause of numerous red tide events in the north of Chile.

It is postulated that the presence of P. gracile along the central Chilean coast is the consequence of a southward displacement of warm waters toward this zone during the "El Niño" Phenomenon of 1982-83. Similarly, its subsequent persistence at these higher latitudes indicates a favourable adaptation to the environmental conditions, assimilating itself with the normal phytoplankton of the area.

Estudio comparativo de la alimentacion de la caballa (Scomber japnicus) en 1979 y durante El Niño 1982-83

by
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Al presentarse el fenómeno El Niño 1982-83, con las fuertes alteraciones de los factores abióticos como temperatura, salinidad, oxígeno y nutrientes; el número de itens en el contenido estomacal de la caballa se incrementó debido a que durante este tiempo muchos organismos marinos ampliaron su distribución horizontal y vertical.

Por otro lado, se determinan y comparan los índices alimentarios de la caballa en un año sin alteraciones ambientales y durante El Niño 1982-83. Asímismo, se establece la relación longitud-peso para ambas épocas determinando el estado de bienestar de la especie.

An Investigation in the Nutritional Strategies of the Deep Water Microbial Microaerophile Thioploca

by
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An extensive microbial mat has been found to occupy the surficial sulfurous sediments in water depths of 100-500 m over the shelf and adjacent slope which are in contact with low-oxygenated waters of the poleward Perú-Chile Subsurface Countercurrent (SCC) off western South America. Fluctuations in this microbial biomass which may be responses to El Niño related changes in the oxygen minimum zone imply that an important microbial ecological role is operative in the upwelling biome. To examine the specific nutritional stratifies of Thioploca spp. new culture techniques have been applied which utilize low oxygen incubations and sulfide-oxygen gradient culture tubes. These methods have been successfully used in the isolation and culture of several related filaments Beggiatoaceae strains. Results from these culture efforts will be described.

Equatorial Upwelling Processes in the Galapagos Islands after the 1982-83 "El Niño"

by
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A virtual disappearance or partial reversal of the Equatorial Undercurrent (Cromwell Current) was reported during the 1982-83 El Niño event both in the central Pacific at 159°W, and in the eastern Pacific at 110°W in January 1983, as well as at 95°W during May 1983. In the oceanic equatorial region, there was a 50-fold decrease in nutrients and a 5-fold decrease in productivity. In November 1983, upwelling of Equatorial Undercurrent water was observed at 92°W. The hydrographic and biological characteristics, east and west of the Galapagos, showed evidence of upwelling in terms of cooling, higher nutrients content and an increase in productivity caused by the fertilization of surface waters. The highest concentration of phytoplankton was west of the Islands; the cells number decreasing north and south of the upwelling area. The diatoms Thalassiotrix delicatula and Nitzschia delicatissima were the most important components of the phytoplankton biomass in the equatorial band.

Comparison of the hydrographic, chemical and biological observations between November 1983 and November 1976 and 1978 indicated that enrichment by equatorial upwelling was stronger in 1983, and that it occurred in a zonal band east and west of the Island.

The El Niño Event and its Influence on the Composition of Zooplankton off Perú

by
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The impact of the El Niño phenomenon on marine resources arises from different causes. Zooplankton - as a source of sustenance, as predators of the eggs and larvae of fish and meroplankton, and as larval stages of economically important crustaceans - have played an important role in the 1982-83 El Niño episode. The analysis of zooplankton in the north central area off Perú in the January-February period of 1983 indicates changes in the species composition of its components, and increase in carnivore species known to prey of fish larvae, and the transport or reproduction of shrimp larvae more than 900 km from their habitual areas of concentration.

A Comparison of Nitrogen Dynamics Observed during El Niño years at Point Conception, California and 15°S, Perú

by
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During the El Niño of 1982-83 the OPUS (Organization of Persistent Upwelling Structures) programme conducted at 6 week cruise to study the upwelling center at Point Conception, California. Undertaken in Spring, 1983, this investigation included measurements of nitrogen uptake using ^{15}N and nitrate reductase activity, taken at productivity stations along sections, along drifter tracks and in large experimental shipboard containers. These data are discussed in the context of a "conveyor-belt" hypothesis in which upwelled algae go through a "shift-up" in metabolism followed by a shift-down. For comparison, data from JOINT II during the El Niño of 1976 at the upwelling center at 15°S, Perú aboard the R/V WECOMA will be presented. There is some evidence that nutrient concentration in the upwelled water affects the duration of shift-up and that the initial nutrient concentration affects the rate of shift-up as well. Consequently, reduced nutrient concentrations in surface waters accompanying El Niño's results in reduced maximum nutrient uptake rates. The space and time scales of nutrient utilization and primary production are lengthened under these circumstances.

The Use of HPLC for Evaluating El Niño Effects on Phytoplankton Distributions and Composition

by
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The influence of El Niño events on phytoplankton distributions in the Eastern Pacific Ocean has been shown to be quite dramatic. Biological consequences of El Niño events primarily result from a deepening of the mixed layer which decreases the availability of both light and inorganic nutrients to local phytoplankton populations. During the 1982-83 El Niño, two-to-twenty fold reductions in chlorophyll a concentrations were reported for the eastern equatorial Pacific Ocean. Limited data suggest that phytoplankton composition may have been altered from a diatom-dominated to a flagellate-dominated community. Conventional methods for assessing phytoplankton biomass and composition are either non-specific (fluorometric pigment analysis) or extremely time consuming (microscopic enumeration). In recent years, HPLC pigment analysis has been shown to be an accurate and rapid means of assessing the composition and physiological condition of natural phytoplankton assemblages.

Baseline HPLC pigment data (0-300m) are presented for a trans-Pacific section (24°N) performed during April-May 1985. Distributions of chlorophyll a were in good agreement with previous fluorometric measurements made during non-El Niño years. However, the HPLC results provide additional information regarding the vertical and horizontal variability of phytoplankton composition in coastal waters southwest of San Diego. Phytoplankton shifted from a near-surface diatom-dominated community inshore to a deeper green algal/cyanobacteria dominated community offshore. The potential of using shipboard HPLC pigment methodology for monitoring phytoplankton populations during El Niño events is demonstrated.

Nota sobre la Presencia de Especies Fitoplanctónica como Indicadores de Aguas Cálidas en el Norte de Chile

by
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Se entregan resultados de distribución y abundancia de especies de amphioxus y ostracodos presentes en el planctón durante agosto de 1983.

Antecedentes ampliamente difundidos señalaron como período anómalo el año 1983, por haberse registrado un intenso e inusual evento "El Niño" (Kelly, 1985; Blanco y Días, 1985; Fonseca, 1985; Guillén et al., 1985; Arntz, 1986), que trajó consigo un aumento de la temperatura y salinidad de las aguas de la capa superficial de la zona norte de Chile (Arica-Antofagasta).

Paralelamente al desarrollo de "El Niño" 82-83 se registró la presencia de numerosas especies pelágicas, que normalmente no conforman la fauna de la región (Avaria, 1985; Muñoz, 1985; Kong, 1985; Rojas de Mendiola et al.; Ochoa et al. 1985; Hoyos et al. 1985) entre las cuales se capturaron numerosas larvas de amphioxus y ostracodos pelágicos que no han sido descritos para dicha zona o bien tienen una distribución netamente tropical.

Contribución al Conocimiento del Fitoplanctón Nerítico de la Costa Colombiana (Sector Tumaco-Cabo Manglares)

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La presente nota corresponde a los resultados obtenidos de acuerdo a diferentes análisis cualitativos y cuantitativos de 40 muestras de fitoplanctón, recolectado a lo largo de la plataforma continental colombiana, entre los sectores comprendidos de Tumaco y Cabo Manglares, costa pacífica colombiana.

Un total de 170 especies, entre diatómeas y dinoflagelados son citadas, algunos por primera vez. Se analiza la distribución de especies y grupos en cada estación por medio de tablas de frecuencia y diagramas de distribución, determinando las tendencias generales de las muestras y relacionándolas con algunos parámetros físico-químicos.

Los géneros más abundantes fueron: Chaetoceros, Coscinodiscus, y Skeletonema. Otros géneros que registran numerosas especies son: Nitzschia, Biddulphia, Pleurosigma, Bacteriastrum y Thalassionema. Entre los dinoflagelados sobresale el género Peridinium.

Se evaluó la productividad primaria en algunas zonas de manglares, (Rhizophora mangle y Laguncularia racemosa) obteniéndose valores promedios máximos de 320.10 mg.C./m3/h. de fotosíntesis bruta y 32.17 mg.C./m3./h. de fotosíntesis neta, y una productividad mínima promedio de 7.10 mg.C./m3./h. para la fotosíntesis neta y 90.34 mg.C./m3./h. para la fotosíntesis bruta. El carbono orgánico varió de 3 a 7%, pudiendo alcanzar hasta 11% mientras los valores de nitrógeno quedaron entre 0.11 y 0.12 %. Los altos valores de la relación C/N. generalmente superiores a 14, traducen la abundancia de detritos vegetales en los sectores estudiados, lo que nos permite considerarlos zonas de alta productividad.

Fluctuations in the Abundance of Brown Macroalgae in the North of Chile between 1979 and 1986

by
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The fluctuations in the abundance of the sporophytes of Lessonia nigrescens, Lessonia trabeculata and Macrocystis integrifolia have been studied for the 1979-86 period between the latitudes 21°30'S and 23°26'S.

L.nigrecens had a density of 8.39±3.86 plants per alongshore meter of rocky substrate in 1986, forming a belt along the lower level of the intertidal zone. In February 1983 its disappearance had been total. By April 1986 its recovery was patchy, due to the grazing effects of Chiton granosus, Acanthopleura nigra and Fissurella limbata, as well as to the orientation of the rocky substrate to wave attack.

M.integrifolia totally disappeared totally disappeared at the end of 1982 and began a recovery in 1984. It again disappeared totally that same year, decimated by the black urchin (Tetrapigus niger), which was recruited during the 1982-83 El Niño (Tomicic 1985). In April 1986 there were only patches of this algae in the sublittoral of the study region.

L.trabeculata was affected by the 1982-83 El Niño only in the upper part of its depth distribution and began a rapid recovery in 1984. However, there was a second and much more drastic decrease after the 1982-83 El Niño due to the grazing effects of T.niger. In April 1986 there were places (e.g., Bahia de Mejillones) where the presence of thousands of young plants that are colonizing the hard substrated of the bottom could be observed.

Pterópodos y heterópodos del mar ecuatoriano durante 1985 y 1986

by
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Se estudian los Pterópodos y Heterópodos del mar ecuatoriano en los meses de septiembre de 1985 y febrero de 1986.

Su relación con los parámetros físicos, químicos y meteorológicos, nos permiten detectar el desplazamiento de masas de aguas, afloramientos y el estado actual del Océano para las épocas mencionadas. Además, se muestra con mapas, la distribución, abundancia y diversidad de estos moluscos planctónicos en el Pacífico Este.

The Nitrate-Silicate relationship during the 1982-83 El Niño

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The 1982-83 El Niño presented characteristics very different from those of previous events, giving rise to unusual changes in the marine ecosystem. One result of this variation was observed in the nutrient distribution: the N/Si rate had extremely low values compared with average conditions, associated with a low biological production. The concentration of nitrates was lower than that of silicates, resulting in the modification of the distribution and composition of the phytoplankton. The results are compared with those for the 1972-73 El Niño and for normal years.

Chlorophyll in the Upwelling Areas of Chimbote and San Juan during the 1982-83 El Niño

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The phytoplankton biomass in the upwelling areas of Chimbote and San Juan during the last El Niño event had abnormal characteristics, including distributions and compositions that were related to abnormally low levels of nutrients. The changes in primary production had negative effects on other trophic levels and pelagic fishes, reflecting an overall transformation of the upwelling ecosystem. The chlorophyll distributions are compared with those of other upwelling areas, both in normal tides and during the development of the El Niño episode.

EFFECTS OF EL NINO ON RECRUITMENT AND FISHERIES PROCESSES

The Fishery of the Common Sardine (Clupea benticki) and the 1972-73 El Niño

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We have done an age-group analysis of an historical 13 year series of relative abundance (1965-1978) for the common sardine (Clupea benticki) in the area of Talcahuano. Based on the age-class composition in the catches, our analysis shows variations in age-specific survival, with changes in the age structure of the population.

Variations in fishing effort do not totally explain the patterns of survival fluctuations in the different age groups, for which reason we have correlated the series with El Niño events finding a strong relation with the 1972-73 episode, a time of strongest departure from normal within the study period. We observe, moreover, that the population response to increments in fishing effort was different than the response to El Niño events. The differences are manifested mainly in the alteration of the age structure and recruitment levels of the population.

We attempt to explain these distinct population responses from an ecological and evolutionary perspective, keeping in mind that we are dealing with a population having demographic characteristics and a life strategy of great adaptive capacity in a highly variable environment. The environmental variability is associated with the long-term instability in abundance, and its effects on the regulation of the fishery and risk of exploitation of the common sardine in the Talcahuano zone.

Effects of El Niño on the Distribution and Recruitment of the Peruvian Hake (Merluccius gayi peruanus)

by
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Espino et.al. (1985) have postulated that El Niño favours the recruitment of the Peruvian hake. On the other hand, the results of virtual population analysis (VPA) for the years 1971-1982 yield a fit to the stock-recruitment relation (Richter, 1954) of r=0.70; this is not satisfactory because it is influenced by variations in the distribution area of the species that affect the population density of adults (Espino et.al., 1984).

Defining oxygen concentrations of less than 0.25 ml/L as limiting the hake distribution, the seasonal variation of this limit for the period 1981-85 has been established on the basis of cruise date. Using this, the

size of the area of distribution was calculated. Taking the normal values of summer, autumn and spring as a standard, seasonal area variation indices (AVI) were determined and a relation between these and sea surface temperature was established. This allows us to make a proxied extrapolation for the years 1971-1982.

With the seasonal, proxied AVIs and the VPA biomass (B) we obtained adult densities (B/km2) that, when applied to the stock-recruitment relation, gave a fit with r=0.97. This confirms that fluctuations in the recruitment of the Peruvian hake are favourably influenced by changes in its distribution during El Niño, since during these events the AVI increases, reducing the population density in proportion to the intensity of the phenomenon.

Sea Surface Temperature and Salinity Variations off Northern Chile during the El Niño in relation to Fish Fluctuations

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A graphical sequence is shown of sea surface temperature and sea surface salinity gathered in monthly monitoring oceanographic cruises off the Northern Chilean Coast during the El Niño of 1982-83. Three phases are clearly seen: an initial phase, followed by an intensification period or "climax" of the event, to conclude in a declination and ending period. Charts of fish distributions based on reports of fishing logs allow us to see changes in distribution directly related with environmental changes.

There is a brief discussion of previous El nino events in the area in relation with changes in fish distribution, concluding that each El Niño phenomenon affects the fish population differently.

We must emphasize the value of maintaining periodical monitoring surveys of the environment to detect the early occurrence of El Niño along the northern coast of Chile in order to achieve a better handling of fishing activities.

Feeding Variations of the Sardine (Sardinops s.sagax) in the years 1980-1984 along the Peru Coast

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The oceanographic changes produced during the 1982-83 El Niño phenomenon caused qualitative and quantitative changes in the primary and secondary trophic levels along the Peru coast. These changes have produced variations in the food composition of planktogenous species, such as the Peruvian sardine Sardinops s.sagax.

In this paper we present the variations in the feeding coefficient of the sardine in the zones of Paita, Callao, Pisco and Ilo, and the negative effects on the biological condition of the species (Fulton Condition Factor). Also presented are the qualitative variations in the diet observed before and after the 1982-83 El Niño phenomenon, throughout the areas of study.

Changes in the Thermal and Saline Structures in the Northern Zone of Chile and their relation to the Distribution of Spanish Sardine (1981-1986)

by
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The Spanish sardine is the principal fisheries resource in the northern zone of Chile since 1976, reaching unprecedented catch volumes. This zone is characterized by strong temperature and salinity gradients within 40 miles of the coast. On occasions this structure is altered by strong oceanic and climatic changes, inducing changes in the spatial distribution of the fisheries resources.

This paper shows the changes that have occurred in the temperature and salinity structures in the northern zone of Chile between 1981 and 1986 and their effects on the distribution of Spanish sardine. Oceanographic cruises and acoustic surveys conducted between Arica (18°30'S) and Caldera (27°00'S) from 1981 through 1986 are analyzed.

A strong thermal anomaly between December 1982 and August 1983 can be clearly seen, while the thermocline and 15°C isotherm were depressed to a maximum depth of 150 m in May 1983. The surface salinity reached values never recorded in the zone (35.8°/oo) and values over 35.3°/oo dominated the study region between December 1982 and October 1983. The Spanish sardine had a distribution characterized by high concentrations near the coast between December 1982 and August 1983, which differs from what has been observed in previous years.

Effects of the 1982-83 El Niño Phenomenon on the Titi Shrimp Xiphopeneus riveti along the Peru Coast

by
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During the 1982-83 El Niño there occurred a series of changes along the Peru coast that created a completely new situation in respect of the distribution, behaviour, abundance, etc. of renewable natural resources, exploited and potential Xiphopeneus riveti is a resource that is normally distributed along the Peru coast north of 6°S and its catches are small,

less that 50 MT annually. The El Niño phenomenon noticeably favoured the reproduction and recruitment of this shrimp, extending its distribution area to the Peru-Chile border (18°S). The catches increased from north to south, being on the order of 500 MT during the last three months of 1982 in the northern zone (03°30'S-06°00'S) and reaching 16,200 MT during 1983 along the entire coast, with a commercial value of over 15 million dollars.

Some Evolutionary Implications of Protracted El Niño Events in the Colonization and Ecological Balance of Fish Populations in the Galapagos Archipelago

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Preliminary observations in the Galapagos Archipelago, following the 1982-83 El Niño event, showed an increase in the population size of tropical and subtropical species of fishes. A corresponding reduction in the populations of endemic species and those species with zoogeographic affinities with the ichthyofauna of Peru and Chile was also documented. Additional collections in 1984 substantiate these data.

At least one species of fish, Chaetodon kleini, was recorded in the East Pacific for the first time at the Galapagos in 1984; The arrival of this Indo-Pacific butterflyfish at the Galapagos is attributed to the recent, large scale El Niño event.

Disappearance of the Giant Squid (Dosidicus gigas) Fishery in the Gulf of California, and its possible relation to Overfishing and the Effects of "El Niño"

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The fishery of Giant Squid (Dosidicus gigas) in the Gulf of California achieved a remarkable development during 1978-80, increasing from a production of 2,000 metric tons in first year to 22,400 in 1980. This notable increase was intimately associated with the application of a greater fishing effort. In 1981, the catches underwent a very significant decrease, bringing about the crisis of the fishery, and from 1982 onwards, the resource was no longer present in the Gulf, terminating thus its exploitation.

In this study, the possible causes for the disappearance of Dosidicus gigas from the Gulf of California are discussed in relation to the overfishing effect as well as to probable changes in the effect of the "El Niño" 1982-83.

Recuperation of the Coastal Communities of the Northern Zone of Chile after "El Niño" Phenomenon 1982-1983

by
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This study presents and discusses the changes that have taken place in the structure of the coastal communities of Northern Chile (I. Region) as a result of the "El Niño" phenomenon in 1982-83, based on qualitative and quantitative observations of some species of the typical flora and fauna. For the purpose of visualizing the actual conditions of these coastal communities, we present the following relevant points and observations:

A. Repopulation of the native species: at a larger stage the event can be observed by the loss of opportunist species and the success in the recovery of the ecological nests by the native species.

B. Alterations in trophic features: alterations in the nutrition preferences are observed, especially in fish in a partial or radical way.

C. Competition: principally for habitat.

The slow return to stability of the coastal community structure is actually favoured by the predominant environmental factors and by the absence of foreign species incorporated into the coastal system during "El Niño" phenomenon in 1982-83.

Un análisis sobre las causas del colapso de la pesquería de anchoveta (Engraulis ringens) realizada en la zona norte de Chile

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Se analizan relaciones entre la captura, la captura por unidad de esfuerzo (C.P.U.E.) y el esfuerzo total de la pesquería de anchoveta (Engraulis ringens) realizada en la zona norte de Chile (18°30'S-24°S) entre 1959 y 1977. Al mismo tiempo se examinan, para el período 1957-1975, relaciones entre el índice de abundancia relativa (C.P.U.E.) y la temperatura superficial del mar como característica del medio.

Del examen del modelo de producción general se desprende que el esfuerzo de pesca fue notablemente incrementado después de 1963, situándose la pesquería al lado derecho de la curva de producción y la abundancia del recurso en un nivel inferior al óptimo requerido para alcanzar la captura máxima de equilibrio.

Por otra parte, de la relación entre la C.P.U.E. y la temperatura superficial del mar del mismo año, se deduce que los períodos frios y especialmente los períodos cálidos afectarían la disponibilidad y por lo tanto la vulnerabilidad de la anchoveta. Mientrás que de las relaciones entre la C.P.U.E. y la temperatura superficial del mar retrazada en uno y dos años, se desprende que los períodos cálidos y frios habrían afectado el reclutamiento y por ende la abundancia del recurso en los años siguientes.

Finalmente se concluye que durante el período 1957-1975 el recurso fue afectado por 6 fenómenos "El Niño", 4 de los cuales fueron de gran intensidad (1957, 1958, 1965 y 1972-73), y por 7 años frios. Estos eventos, además de la explotación intensiva realizada después de 1963, habrían influido notablemente en la disminución de la abundancia del recurso y en el posterior colapso de la pesquería.

Biological Effects off Ecuador during the 1982-83 El Niño

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The strong El Niño event of 1982-83 had a clear effect on the biological productivity off Ecuador during this event. Low productivity of plankton extended along the coast of Ecuador replacing the highly productive water normally associated with the Equatorial Front and the areas associated to coastal upwelling. Low chlorophyll a concentration, a low primary production, a decrease in diatoms cells numbers, and a low zooplankton biomass were associated with this water.

Spatial and temporal changes in abundance, composition and distribution of the most important species of fish such as Sardinops sagax, Etrumeus teres, Scomber japonicus are analyzed.

The changes are related to the environmental conditions as well as to the increase of catches from the fishing fleet after the El Niño phenomenon.

EFFECTS OF EL NINO ON BIRDS AND MAMMALS AND IMPACTS ON HUMAN ACTIVITIES

Oscillation of Macrobenthos in Shallow Waters of the Peruvian Central Coast Induced by El Niño 1982-83

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In the Bay of Ancon, north of Lima, macrozoobenthos was sampled at 15 m (January 1982 - September 1984). Fluctuations in density, biomass, species composition and diversity of the fauna as well as those of the environmental factors, temperature, salinity and dissolved oxygen were analysed. El Niño (EN) 1982-83 induced marked positive effects at both depths. Some of these changes persisted in 1984 due to the increase of oxygen close to the sea-floor and its persistence during and after the phenomenon. At 15 m the species number, which before EN fluctuated between 3 and 17, increased to > 26 (max. 45) during EN and in the months following the event. Biomass reached 156 g m^{-2} (wet wt.) in December 1982. Density, normally < 4000, increased to 43,000 and diversity nearly doubled, remaining high until June 1984. Species number at 34 m (0-2 before EN) fluctuated between 15 and 24 from December 1982 to February 1983 and returned to 1-2 as of June 1984. Biomass reached 52 g m^{-2} in December 1982. Density, usually < 600, increased to 13,500, and diversity at this depth nearly tripled in February 1983.

Impact of the 1982-83 El Niño Phenomenon on Agricultural Production in Perú

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Agricultural production during the 1982-83 agricultural season was drastically reduced by the action of excessive precipitations along the northern coast of Peru, as well as by high temperatures in the northern and central coast, associated with a drought in the southern mountains.

The great impact on agricultural activity is due primarily to high losses of seeded surfaces, and secondarily to low crop yields, or, in some cases, to the interruption of the crop development cycle due to thermal effects.

This study presents the results of the analysis of the seedings, harvests and production during the period of occurrence of the 1982-83 El Niño phenomenon, compared with the production figures for agricultural seasons before and after the reference period.

El Niño and Fur Seal Lactation Strategies

by
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Changes in availability of pelagic fishes brought about by El Niños (ENs) directly affect the fur seals' foraging success and may ultimately affect their breeding success: a decrease in food availability, presumably reduces the supply of milk available to offspring and/or increases the risk of mortality of young starting to forage independently. Thus, young able to obtain milk from their mothers throughout ENs would have a higher probability of survival than young weaned under EN conditions. The South American fur seal (Arctocephalus australis) in Peru and the Galapagos fur seal (A. galapagoensis) show the longest lactations among all fur seals: while all other species wean their young before they are 1 year old, in these 2 populations a high proportion of females continue nursing their offspring into a second and even a third year. This extended duration of lactation appears to be an adaptation to El Niño-related environmental uncertainty. To support this idea, the lactation strategies of 8 spp. of fur seals and the California sea lion (Zalophus californianus) are compared: only the species subjected to EN (Galapagos, and Peruvian fur seals and California sea lion) or similar phenomena (S. African fur seal, A. pusillus) show extended lactations. The possible implications on breeding rates are discussed.

Fluctuations in the Principal Components of the Shallow Water Ecosystem along the Central Peru Coast during 1981-84

by
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From May 1981 to August 1984, monthly samples of phytoplankton, meroplanktonic larvae, soft and hard substrate benthos, swimming crabs and fishes have been taken from Ancon Bay (Ancon is located near 12°S, a short drive north of Lima). Simultaneously, hydrographic data were also taken.

The analysis detected fluctuations in the various components of the ecosystem before, during and after the 1982-83 El Niño. Similarly, we were able to establish the impacts on biological variations of such abiotic factors as: changes in the circulation patterns of the surface water masses, sea level, temperature, upwelling and oxygen concentration. The principal mechanisms and processes that govern the observed biological fluctuations during El Niño are discussed. Finally, we draw conclusions regarding the existence of particular mechanisms of importance in areas very close to shore.

Demographic, Reproductive and Physiological Changes in the Marine Bird Populations in the North of Chile Caused by the 1982-83 El Niño

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During the 1982-83 EL Niño and successive years (1984-86) we have monitored the coastal bird populations (Pelecanus occidentalis, Phalacrocorax bougainvilli, Ph. olivaceus, Ph. gaimardi, Sula variegata, Sphenicus humboldti and Larus modestus). To do this we annually surveyed a coastal sector of about 200 km (21°54'S to 23°05'S). Additionally, from 1979 to 1985 we studied the gonadic state, lipid storage, displumage, behaviour and reproductive activity of L. modestus in the same sector.

The results establish the demographic succession of these communities in accordance with thermal processes and food availability. Each population has a different life history strategy in its reproductive and distributional aspects. Among these, P. occidentalis feeds opportunistically on prey of low competitive level and accommodates its nest-making spatially and temporally according to factors of competition and availability.

The data obtained on L. modestus shows physiological changes that occurred during the El Niño episode, in comparison with prior and later years. It was observed that the effects on reproduction persisted until 1984 with a changed regime of displumage and lipid storage. There was no recruitment until 1985, the year in which the population returned to the situation observed in 1979-81.

Photographs and figures are used to support the presentation and discussion of the paper. This project has been partially financed with funds from DIEXAT-Universidad de Antofagasta, from the National Science Foundation (Travel Grant L.C.F.) and from North Texas State University.

The Impact of the 1982-83 El Niño-Southern Oscillation on Seabirds in the Galápagos Islands

by
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From October 1982 through July 1983 the Galapagos Islands experienced the strongest ENSO event yet recorded, with heavy rains and a warm, unproductive ocean. During this period most seabirds did not breed and many left the archipelago altogether. Dark-rumped Petrels (Pterodroma phaeopygia), which did breed during the event, demonstrated low growth rate of chicks. Censuses and observations demonstrate substantial population decreases of other seabirds during ENSO. One hundred thirty seven nesting pairs of Blue-footed Boobies (Sula nebouxi) were counted at Punta Cormorant, Floreana Island in October 1982, but only 63 in September 1984. Total censuses of Galapagos Penguins (Spheniscus mendiculus) and Flightless Cormorants (Nannopterum narrisi) taken before and after the ENSO demonstrated declines of 77% and 49%, respectively. We discussed the seabird population declines during ENSO and their subsequent recovery.

ANNEX IV

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ANNEX V

LIST OF ACRONYMS AND ABBREVIATIONS

AOML	Atlantic Oceanographic and Meteorological Laboratory (NOAA)
BID	Banco Interamericano de Desarrollo
CCCO	Committee on Climatic Changes and the Ocean
CIOH	Centro de Investigaciones Oceanográficas e Hidrográficas
CPPS	Comisión Permanente del Pacífico Sur
ECMWF	European Center for Medieu-Term Weather Forecasts
ELNAR	El Niño in the Ancient Record
ERFEN	Regional Investigation of the Phenomenon El Niño (Colombia, Chile, Ecuador, Perú)
GLOSS	Global Sea-Level Observing System
GOS	Global Observing System
IDRC	International Developoment Research Center
IGOSS	Integrated Global Ocean Services System
IMARPE	Instituto del Mar del Perú
INP	Instituto Nacional de Pesca (Ecuador)
IODE	International Oceanographic Data Exchange, IOC Working Committee on IODE
IOC	Intergovernmental Oceanographic Commission
IPGH	Instituto Panamericano de Geografía e Historia
ISLP	IGOSS Sea Level Project
JSC	Joint Scientific Committee (WMO/ICSU)
MMS	Marine Meteorological Services
NOAA	National Oceanic and Atmospheric Administration (USA)

OOSDP	Ocean Observing System Development Programme
OPC	Ocean Processes and Climate
OSLR	Ocean Science in Relation to Living Resources
RTH	Regional Telecommunications Hub
SARP	Sardine/Anchovy Recruitment Project
SCOR	Scientific Committee on Oceanic Research
SWFC	South-West Fisheries Center, National Marine Fisheries Service (NOAA)
TEMA	Training, Education and Mutual Assistance
TOGA	Tropical Ocean and Global Atmosphere Project
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WWW	World Weather Watch

No.	Title	Publishing Body	Languages
32 Suppl.	Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR) Halifax, 26-30 September 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa) Tenerife 12-17 December 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific Suva, Fiji, 3-7 October 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36	IOC/FAO Workshop on the Improved Uses of Research Vessels Lisbon, 28 May - 2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36 Suppl.	Papers submitted to the IOC-FAO Workshop on Inproved Uses of Research Vessels Lisbon, 28 May-2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37	IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region Basrah, Iraq, 8-12 January 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific Suva, Fiji, 24-29 September 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
40	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications Sidney, B.C., Canada, 29-31 July 1985 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2) Dakar, Senegal, 28 October - 1 November 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
42	IOC/UNEP Intercalibration Workshop on Dissolved/Dispersed Hydrocarbons in Seawater Bermuda, USA, 3-14 December 1984 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean Venice, Italy, 23-25 October 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
44	IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
45	IOCARIBE Workshop on Physical Oceanography and Climate Cartagena, Colombia, 19-22 August 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
46	Reunión de Trabajo para Desarrollo del Programa «Ciencia Oceanica en Relación a los Recursos No vivos en la Región del Atlantico Sudoccidental Porto Alegre, Brazil 7-11 de Abril de 1986 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	Spanish
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence Townsville, 1-6 December 1986 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on "Ocean Science in Relation to Non-Living Resources (OSNLR)"	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on "El Niño" Guyaquil, Ecuador, 27-31 October 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English