

Final report on Pak-US Cooperative Program in Oceanography, supported by the US-ONR under Grant N00014-86-86-G-0230

The primary goal of the Pak-US Cooperative program was to understand the processes involved in the interaction between the physics, chemistry and biology of the water off Pakistan during inter, intra and post monsoonal periods. This study helped to understand and predict applied aspects of oceanography such as fisheries productivity and pollution damage to the environment.

The program was a multi-dimensional approach to ocean research, probably the first time attempted in Pakistan at this scale. In the process of designing the program, the main features that were taken into consideration were to investigate the influence that the monsoons have on the major physical forces of the area and to try to study how these influenced the biology here.

The area that was covered in the study was fairly extensive, from 20-25 °N and 59-67 °E. The cruise tract was 1500 nautical miles, it started from Karachi, went over the Murray Ridge upto the Oman's continental shelf and then back to the Pasni coast. There were sixty two oceanographic stations. A number of cruises have been carried out, to cover the various monsoon periods of the year. Extensive data and samples have been obtained and processed since, some of which have been presented to colleagues at seminars, conferences and appear as publications both locally as well as internationally. The list of publications and bibliography is appended, copies of any or all of the papers can be made available accordingly.

The processed data collected during the oceanographic cruises from the North Arabian Sea has also been included in the data base of the International Joint Global Ocean Flux Study (JGOFS).

Recently, the National Institute of Oceanography, Pakistan organized a seminar from January 22 and 23, 2001, to provide an opportunity to the scientists involved in the Pak-US Cooperative program to share their research findings with their colleagues.

The National Institute of Oceanography and the Ministry of Science and Technology, Government of Pakistan acknowledges the contributions of the US ONR in developing basic research capacities in marine science in Pakistan through the multi-year grants. I, as the principal investigator of the Pak-US program would also like to acknowledge the assistance of Dr Bernard J. Zahuranec who provided administrative oversight. I also acknowledge the scientific assistance given by US scientists to the marine scientists in Pakistan.

The Pak-US programme was supported by the US Office of Naval Research, under Grant N00014-86-86-G-0230. The funds provided under Pak-US Cooperative Programme in Oceanography of the Arabian Sea have been fully utilized.

BIBLIOGRAPHY OF PAK-US COOPERATIVE PROGRAM IN OCEANOGRAPHY PUBLICATIONS

RESEARCH PAPERS

REFEREED PUBLICATIONS

The effect of momentum and buoyancy fluxes on the mixed layer depth and their influences on the primary productivity of the North Arabian Sea, during the northeast and southwest monsoons of 1992

(Tariq M. Ali Khan, Samina Kidwai and Shahid Amjad. Accepted Pakistan Journal of Marine Biology 2001)

Abundance and distribution of ichthyolarvae from upper pelagic waters of the northwestern Arabian Sea during different monsoon periods, 1992-1994

(Samina Kidwai and Shahid Amjad. ICES J. mar Sci. 58:3:719-724, 2001)

Zooplankton: pre-southwest and northeast monsoons of 1993 to 1994, from the North Arabian Sea

(Samina Kidwai and Shahid Amjad. Marine Biology 136:3:561-571, 2000)

Spreading of Persian Gulf water in the Northwestern Arabian Sea during the month of January

(Arshad Ali and Naeem Ahmed Syed. Pakistan Journal of Marine Sciences 8:1:1-9, 1999)

Seasonal variation of mixed layer depth in the North Arabian Sea

(Arshad Ali, Naeem Ahmed Syed, Labeed I. Kazi, S. Mohsin Tabrez, Shahid Amjad. Pakistan Journal of Marine Sciences 4:1:1-4, 1995)

Heat budget studies of Northern Arabian Sea during summer and winter seasons, 1992

(Tariq, Masood Ali Khan, J.D. De Las Alas, Mariano A Estoque and S.H. Niaz Rizvi. Pakistan Journal of Marine Sciences 4:2:81-90, 1995)

An overview of the meteorological conditions over the North western Arabian Sea during northeast and southwest monsoon, 1992

(Tariq Masood Ali Khan, Shahid Amjad, S.H. Niaz Rizvi, Arshad Ali, Manzar Salam. Science Technology and Development 13:1,1994)

Pakistan and US conduct Cooperative Research Programme in North Arabian Sea

(Saiyad I. Ahmed, Shahid Amjad and S.H.Niaz Rizvi. US JGOFS News 5:2:1993)

PUBLISHED IN CONFERENCE PROCEEDINGS

Changes in biomass and size-fractionated primary productivity in the Northern Arabian Sea in response to winter and summer monsoons

(Saiyad I. Ahmed, Nuzhat Khan, Monawwar Saleem, Arshad Ali. In: The Arabian Sea Living Marine Resources and Environment (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 479-495, 1995)

Impact of monsoon reversal on zooplankton abundance and composition in the northern Arabian Sea

(Shahid Amjad, M.Ejaz Khan, Mahmood A. Hashmi, A.D. Shah and Tariq Masood Ali Khan. In: The Arabian Sea Living Marine Resources and Environment (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 497-508, 1995)

Bioluminescence and growth rates of heterotrophic dinoflagellates on varying algal diets: Implications for studies of bioluminescence in the Arabian Sea

(Edward J. Buskey. In: The Arabian Sea Living Marine Resources and Environment (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 149-160, 1995)

Quality of marine air over the open Northern Arabian Sea

(B. Ghauri, K.R. Fawz ul Haq, Manzar Salam, M.I. Mirza. In: The Arabian Sea Living Marine Resources and Environment (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 609-617, 1995)

Latitudinal variations of air-sea fluxes during the southwest and northeast monsoons over the Northern Arabian Sea

(Tariq Masood Ali Khan, J.G. De Las Alas, S.H. Niaz Rizvi, Arshad Ali and Labeed I. Kazi. In: The Arabian Sea Living Marine Resources and Environment (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 599-607, 1995)

ABSTRACTS

Abundance and distribution of ichthyo-larvae from the upper pelagic waters of north western Arabian sea, during monsoon periods 1992-1994

(Samina Kidwai and Shahid Amjad. Oral presentation at the ICES “ Young Scientists Conference in Marine Ecosystem Perspectives” November 20-24, 1999, Gilleleje, Denmark. In ICES Cooperative Research Report No. 240. ISSN 1017-6195)

The effect of momentum and buoyancy fluxes on the mixed layer depth and their influences on the primary productivity of the North Arabian Sea, during the northeast and southwest monsoons of 1992

(Tariq M. Ali Khan, Samina Kidwai and Shahid Amjad. Poster at the ICES “ Young Scientists Conference in Marine Ecosystem Perspectives” November 20-24, 1999, Gilleleje, Denmark. In ICES Cooperative Research Report No. 240. ISSN 1017-6195)

Deep Chlorophyll maximum and shallow oxygen minimum in relation to mixed layer depth in the Northern Arabian Sea. (Nuzhat Khan and Mohsin Tabrez. Ist GLOBEC Open Science meeting, 17th- 20th March 1998, UNESCO Head Quarters, Paris, France)

Abundance of *Planktonella sol*, in the northern Arabian Sea during the 1992 NE monsoon (Mehr un Nisa, Shahid Amjad, Shaukat H. Khan and Saiyad I. Ahmed. Ist GLOBEC Open Science meeting, 17th- 20th March 1998, UNESCO Head Quarters, Paris, France)

Preliminary study near surface thermal structure response to momentum and heat fluxes in the north Arabian sea

(Tariq M. Ali Khan, Shahid Amjad, Saiyad I. Ahmed, Labeed I. Kazi, Arshad Ali, S. Moazzam Ali, Naeem Ahmed, Mohsin Tabrez. 5th TOS Scientific Meeting “Ocean Interfaces” April 1-4, 1997 Seattle WA, USA ML-42)

Spatial variation of Chlorophyll in the Northern Arabian Sea in response to winter and summer monsoon

(Nuzhat Khan, Shahid Amjad, Mohsin Tabrez and Saiyad I. Ahmed. 5th TOS Scientific Meeting “Ocean Interfaces” April 1-4, 1997 Seattle WA, USA ML-38)

Interannual variability of zooplankton biomass and abundance in the North Arabian Sea

(Samina Kidwai, Shahid Amjad and M. Ejaz Khan. . 5th TOS Scientific Meeting “Ocean Interfaces” April 1-4, 1997 Seattle WA, USA ML-40)

Monsoonal effects on Bacterioplankton distribution and production in the North Arabian Sea

(Mehr un Nisa, Shahid Amjad, Shaukat H. Khan, Monawwar Saleem and Saiyad I. Ahmed. 5th TOS Scientific Meeting “Ocean Interfaces” April 1-4, 1997 Seattle WA, USA ML-41)

Monsoonal reversal and zooplankton diversity of the northern Arabian sea (Shahid Amjad, Hina S. Baig, M. Ejaz Khan and Mahmood A. Hashmi. International Symposium on Biodiversity of Pakistan 7th & 8th November 1995, Islamabad, Pakistan)

Mixed layer variability in the North Arabian Sea under the influence of atmospheric forcing

(Tariq Masood Ali Khan. XXI IUGG General Assembly, July 2-14, 1995, Boulder Colorado, USA)

PAK-US CONFERENCE
on
NORTH ARABIAN SEA ENVIRONMENT and ECOSYSTEM RESEARCH
JANUARY 23&24, 2001, KARACHI, PAKISTAN

PROGRAMME

DAY ONE January 23, 2001

FIRST SESSION Biological Oceanography

Chairperson: Dr. Bernard J. Zahuranec Co-chair: Prof. Dr. Viqar uddin Ahmed

**Shahid Amjad, Javed Baquer, M. Ejaz Khan, Mahmood A. Hashmi,
A.D. Shah, Atiq-ur-Rehman and Samina Kidwai**

Overview of Zooplankton Research: NASEER

Samina Kidwai and Shahid Amjad

Trends of diel migration in zooplankton in the northwest Arabian sea

**Nuzhat Khan , Mohsin Tabrez, Shaukat H.Khan, Mehrunnisa,
Monawwar Saleem and Shahid Amjad**

Chlorophyll dynamics in the northwestern Arabian sea and coastal environment of Pakistan

Mehurnissa and Shaukat H Khan

Seasonal changes in phytoplankton abundance and species composition in the Northwestern Arabian Sea and coastal waters of Karachi, Pakistan

Lunch/Prayer Break

SECOND SESSION Physical Oceanography

Chairperson: Dr. G.S.Quraishee Co-chair: Prof. Dr. S.M.Saifullah

Arshad Ali and Donald Olson

Circulation and water masses over the Murray Ridge in the North Arabian Sea

Naeem Ahmed and Arshad Ali

The presence of an upper salinity maxima in Arabian sea

S. Mohsin Tabrez

Oceanographic data collected during NASEER cruises

Tariq M. Ali Khan, Samina Kidwai and Shahid Amjad

The effect of momentum and buoyancy fluxes on the mixed layer depth and their influence on the primary productivity of the North Arabian Sea during the northeast and southwest monsoons of 1992

Tea Break

THIRD SESSION

Chemical Oceanography and Marine Pollution

Chairperson: Dr. Saiyad I. Ahmed

Co-chair: Prof. Dr. Rashida Qasim

S.H. Niaz Rizvi , Javed Aftab, M. Ejaz Khan and Javed Baquer

Heavy metals in some crustaceans from Karachi coast

Monawwar Saleem and Gary Hitchcock

Nutrient distribution and Primary Productivity of the northwest Arabian sea during southwest and northeast monsoon period

Mehrunissa and Javed Aftab

Monsoonal effects on the bacterioplankton distribution and production in the northern Arabian sea and coastal waters of Karachi

Shaukat H. Khan, Monawwar Saleem, Hossam Adil Zaqoot and Qasim Memon

Preliminary investigations on the status of Petroleum Hydrocarbon and Heavy metal concentrations in marine organisms collected from coastal region of Karachi pollution in coastal environment of Karachi

**NIO Technical Report
November 2000**

**North Arabian Sea Environment and Ecosystem Research (NASEER)
Technical Report:**

**Nutrients, chlorophyll, fractional primary productivity in water column of the
North Arabian Sea in 1992-1994**

**Monawwar Saleem and Shahid Amjad
Department of Chemical Oceanography**

**National Institute of Oceanography
St-47, Block-1 Clifton
Karachi. Pakistan**

Table of Contents

Introduction	-----	2
Methods	-----	3
Nutrient analysis	-----	3
Chlorophyll	-----	3
Primary Productivity	-----	3
Acknowledgements	-----	4
Literature Cited	-----	5

INTRODUCTION

Five cruises were carried out under the Pak-US cooperative project “North Arabian Sea Environment and Ecosystem Research (NASEER) from 1992-1994. The main objective of this project was:

- * To determine the spatial and temporal variation in Bacteria-phytoplankton and Bacteria-Bacteriophage coupling in the Arabian Sea.
- * To quantifying the marked seasonal variation in pigment biomass, primary productivity and nutrients present in the waters of the Arabian Sea in relation to the physical forcing factors.

This seasonal variation, which is poorly documented, must be quantified in both space and time.

During these cruises nutrients, chlorophyll and fractional primary production rates were measured at different stations in the wide area of Northwest Arabian Sea.

Details of cruise dates are given below

- I. 7-25th January 1992 on M/V AGHYAR
- II. 11-25th August 1992 M/V AGHYAR
- III. 13-21st March 1993 on M/V MANGEN
- IV. 11-21st May 1994 on R/V BEHR PAIMA
- V. 18-28th December 1994 R/V BEHR PAIMA

METHODS

Sampling

During these cruises seawater samples were collected with an acoustically triggered rosette (General Oceanic) with 12 bottles (PVC) of 5 liter capacity, each containing silicon rubber tubing as well as O-rings.

Nutrient analysis

Nutrient (nitrite, ammonia, phosphate and silicate) samples were analyzed according to the Parsons et al. (1983) method on the Technicon II Auto analyzer. Nitrate is first reduced with the cadmium column to nitrite and then diazotized with the salfanilamide and mixed with N-1 Naphthylethylene diammine dihydrochloride forming the azo dye

which were measured at 543nm (Spectrometer Shimadzu UV-260). Dissolved Silicate and Phosphate formed blue color complex with the ammonium molybdate in acid medium and the color intensity measured at 810 and 882nm.

Chlorophyll

During the cruises 2.5-3.0 liter samples were filtered on 47mm GF/F filters. Filters were placed in glass vials containing 10 ml of 90% acetone (Merck GR grade), ground with a glass rod and kept overnight in the refrigerator for complete extraction.

Spectrophotometric techniques were used for the analysis as described by Parsons et al. (1984).

Primary productivity

Primary productivity was measured using the C-14 method describe by Steemann-Nielson et al, (1952) modified by Parsons (1984). Triplicate 50 ml of samples were taken in the pre-cleaned Pyrex vial and added to 100 micro liter of 100-200 u Ci (Sodium Bicarbonate), triplicate blanks were also used and samples in-situ incubated 4-6 hours (In pelxi glass box) during the first cruise (January 1992). For the second cruise (August 1992) on-deck incubations (in pelxi glass aquarium) were carried-out at 100%, 30% & 9% light, using the screen which was calibrated with the Light meter (Licor model 185B equipped with a lambda instruments 192S under water quantum sensor). During the incubation, the temperature was maintained at sea surface temperature with control water bath circulator. Incubation was terminated by filtration. These samples were filter (pre-washed) through 15,15 and 20ml through the 0.45 (Millipore HWAP membrane, 1.0, 3.0 and 5.0 micron (Nucleopore) filter paper respectively. Filter papers were placed in the Scintillation vials and then 100µl of 10% HCL was added and left for 1 hour when Scintillation liquid was added the viles were again kept in the refrigerator for at least two to four day for counting. Activity of these samples measured at Beckman scintillation counter (Model LS-6000) and quench correction was by using the channel ratio method. Primary productivity calculated per hour by dividing the incubation time and converting the primary productivity to per day by multiplying the value "10" for the winter monsoon and "12" for the southwest monsoon.

Acknowledgements

We are grateful to Miss Sierra Ishaq and Fazal-ur-Rahim for help with analyzing nutrient samples and thanks also NIO's scientists (Ms. Nuzhat Khan, S.M. Tebraz, M. Danish Arshad Ali) and crewmembers on the M/V Behr Paima, M/V Mangen and M/V Mangen for their Cooperation in this cruise. The NASEER project was funded as a Pak-US Cooperative Program in Oceanography in the Northwest Arabian Sea.

Literature Cited

Steemann-Nielsen, E 1952. The use of radioactive Carbon (C-14) for measuring organic production in the sea. *J. Con. Per. Int. Expl. Mer* 18, 117-136.

Parsons, T. R, Yoshiaki Maita, and C.M Lalli. 1984. *A manual of Chemical and Biological Method for Seawater Analysis*. Pergamon Press, Oxford.

REFEREED PUBLICATIONS

Tariq M. Ali Khan, Samina Kidwai and Shahid Amjad, 2001. The effect of momentum and buoyancy fluxes on the mixed layer depth and their influences on the primary productivity of the North Arabian Sea, during the northeast and southwest monsoons of 1992. *Pakistan Journal of Marine Biology*, Accepted

Samina Kidwai and Shahid Amjad, 2001. Abundance and distribution of ichthyolarvae from upper pelagic waters of the northwestern Arabian Sea during different monsoon periods, 1992-1994. *ICES J. mar. Sci.* 58(3), 719-724

Samina Kidwai and Shahid Amjad, 2000. Zooplankton: pre-southwest and northeast monsoons of 1993 to 1994, from the North Arabian Sea. *Marine Biology* 136(3), 561-571

Arshad Ali and Naeem Ahmed Syed, 1999. Spreading of Persian Gulf water in the Northwestern Arabian Sea during the month of January. *Pakistan Journal of Marine Sciences* 8(1), 1-9

Arshad Ali, Naeem Ahmed Syed, Labeed I. Kazi, S. Mohsin Tabrez, Shahid Amjad, 1995. Seasonal variation of mixed layer depth in the North Arabian Sea. *Pakistan Journal of Marine Sciences* 4(1), 1-4

Tariq Masood Ali Khan, J.D. De Las Alas, Mariano A Estoque and S.H. Niaz Rizvi, 1995. Heat budget studies of Northern Arabian Sea during summer and winter seasons, 1992. *Pakistan Journal of Marine Sciences* 4(2), 81-90

Tariq Masood Ali Khan, Shahid Amjad, S.H. Niaz Rizvi, Arshad Ali, Manzar Salam, 1994. An overview of the meteorological conditions over the North western Arabian Sea during northeast and southwest monsoon, 1992. *Science Technology and Development* 13(1), ...

Saiyad I. Ahmed, Shahid Amjad and S.H. Niaz Rizvi, 1993. Pakistan and US conduct Cooperative Research Programme in North Arabian Sea. *US JGOFS News* 5(2), 13-14

PUBLISHED IN CONFERENCE PROCEEDINGS

Changes in biomass and size-fractionated primary productivity in the Northern Arabian Sea in response to winter and summer monsoons

Saiyad I. Ahmed, Nuzhat Khan, Monawwar Saleem, Arshad Ali, 1995. In: *Proceedings of the PAK-US Conference on Arabian Sea Living and Marine Resources and Environment*, 20-24 June 1993, Karachi, Pakistan (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 479-495

Impact of monsoon reversal on zooplankton abundance and composition in the northern Arabian Sea
Shahid Amjad, M. Ejaz Khan, Mahmood A. Hashmi, A.D. Shah and Tariq Masood Ali Khan, 1995. In: *Proceedings of the PAK-US Conference on Arabian Sea Living and Marine Resources and Environment*, 20-24 June 1993, Karachi, Pakistan (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 497-508

Bioluminescence and growth rates of heterotrophic dinoflagellates on varying algal diets: Implications for studies of bioluminescence in the Arabian Sea

Edward J. Buskey, 1995. In: *Proceedings of the PAK-US Conference on Arabian Sea Living and Marine Resources and Environment*, 20-24 June 1993, Karachi, Pakistan (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 149-160

Quality of marine air over the open Northern Arabian Sea

B. Ghauri, K.R. Fawz ul Haq, Manzar Salam, M.I. Mirza, 1995. In: *Proceedings of the PAK-US Conference on Arabian Sea Living and Marine Resources and Environment*, 20-24 June 1993, Karachi, Pakistan (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 609-617, 1995

Latitudinal variations of air-sea fluxes during the southwest and northeast monsoons over the Northern Arabian Sea

Tariq Masood Ali Khan, J.G. De Las Alas, S.H. Niaz Rizvi, Arshad Ali and Labeed I. Kazi, 1995. In: Proceedings of the PAK-US Conference on Arabian Sea Living and Marine Resources and Environment, 20-24 June 1993, Karachi, Pakistan (eds Mary-Frances Thompson and Nasima M. Tirmizi) pp. 599-607

ABSTRACTS

Abundance and distribution of ichthyo-larvae from the upper pelagic waters of north western Arabian sea, during monsoon periods 1992-1994

(Samina Kidwai and Shahid Amjad. Oral presentation at the ICES “Young Scientists Conference in Marine Ecosystem Perspectives” November 20-24, 1999, Gilleleje, Denmark. In ICES Cooperative Research Report No. 240. ISSN 1017-6195)

The effect of momentum and buoyancy fluxes on the mixed layer depth and their influences on the primary productivity of the North Arabian Sea, during the northeast and southwest monsoons of 1992

(Tariq M. Ali Khan, Samina Kidwai and Shahid Amjad. Poster at the ICES “ Young Scientists Conference in Marine Ecosystem Perspectives” November 20-24, 1999, Gilleleje, Denmark. In ICES Cooperative Research Report No. 240. ISSN 1017-6195)

Deep Chlorophyll maximum and shallow oxygen minimum in relation to mixed layer depth in the Northern Arabian Sea. (Nuzhat Khan and Mohsin Tabrez. Ist GLOBEC Open Science meeting, 17th- 20th March 1998, UNESCO Head Quarters, Paris, France)

Abundance of *Planktoneilla sol*, in the northern Arabian Sea during the 1992 NE monsoon

(Mehr un Nisa, Shahid Amjad, Shaukat H. Khan and Saiyad I. Ahmed. Ist GLOBEC Open Science meeting, 17th- 20th March 1998, UNESCO Head Quarters, Paris, France)

Preliminary study near surface thermal structure response to momentum and heat fluxes in the north Arabian sea

(Tariq M. Ali Khan, Shahid Amjad, Saiyad I. Ahmed, Labeed I. Kazi, Arshad Ali, S. Moazzam Ali, Naeem Ahmed, Mohsin Tabrez. 5th TOS Scientific Meeting “Ocean Interfaces” April 1-4, 1997 Seattle WA, USA ML-42)

Spatial variation of Chlorophyll in the Northern Arabian Sea in response to winter and summer monsoon

(Nuzhat Khan, Shahid Amjad, Mohsin Tabrez and Saiyad I. Ahmed. 5th TOS Scientific Meeting “Ocean Interfaces” April 1-4, 1997 Seattle WA, USA ML-38)

Interannual variability of zooplankton biomass and abundance in the North Arabian Sea

(Samina Kidwai, Shahid Amjad and M. Ejaz Khan. 5th TOS Scientific Meeting “Ocean Interfaces” April 1-4, 1997 Seattle WA, USA ML-40)

Monsoonal effects on Bacterioplankton distribution and production in the North Arabian Sea

(Mehr un Nisa, Shahid Amjad, Shaukat H. Khan, Monawwar Saleem and Saiyad I. Ahmed. 5th TOS Scientific Meeting “Ocean Interfaces” April 1-4, 1997 Seattle WA, USA ML-41)

Monsoonal reversal and zooplankton diversity of the northern Arabian sea (Shahid Amjad, Hina S. Baig, M. Ejaz Khan and Mahmood A. Hashmi. International Symposium on Biodiversity of Pakistan 7th & 8th November 1995, Islamabad, Pakistan)

Mixed layer variability in the North Arabian Sea under the influence of atmospheric forcing

(Tariq Masood Ali Khan. XXI IUGG General Assembly, July 2-14, 1995, Boulder Colorado, USA)