Proceedings of the Seminar on

REMOTE SENSING IN MARINE RESOURCES

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Edited by

A K S Gopalan

Space Applications Centre (ISRO), Ahmedabad 380 053

E G Silas

Central Marine Fisheries Research Institute, Cochin 682 018

Indian Space Research Organisation
Indian Council of Agricultural Research
Ministry of Agriculture

Foreword

The Space Research Programme in India is applications oriented and the decision to launch an Indian Remote Sensing Satellite IRS-1, in 1986, is a major step forward. India is a vast country, full of resources and it has been recognised that for the management of these resources timely information is an important factor. Space based remote sensing technique promises such timeliness and for a National Natural Resources Management System (NNRMS) it is envisaged to have a hybrid information system consisting of an optimum mix of remote sensing based system as well as conventional systems.

Marine resources development, specifically, Fisheries development is one of the major areas demanding immediate attention. In this field work carried out in other countries have shown that remote sensing can be successfully used in mapping and monitoring of ocean features like thermal fronts, eddies, upwelling, concentration of sediments and biomass. For locating probable areas in the ocean having fish schools such information is very useful. With this in view and for learning the use of remote sensing in marine fish resources a project was carried out in the early seventies, the UNDP/FAO/GOI Pelagic Fisheries Project.

When a decision was taken to plan for an Indian Remote Sensing Satellite, in 1979, a decision was also taken to conduct Joint Experiments with the actual users so as to provide data for optimising the sensor parameters for the IRS as well as jointly develop the operational methodology for different remote sensing applications in the country. One such Joint Experimental Project for Marine Resources and Fisheries Survey has been conducted, in a comprehensive manner, jointly by Central Marine Fisheries Research Institute (CMFRI) of the ICAR, Fishery Survey of India (FSI) of the Ministry of Agriculture and the Space Applications Centre (SAC) of ISRO. The present seminar is planned to discuss and review the results of this joint experiment to help in planning the future work for the utilisation of the IRS-1 data.

The results presented in this proceedings bring out the techniques and methodologies developed for the primary sea truth data collection and extraction and mapping of biological parameters from airborne and spaceborne sensors. Efforts have been made in the difficult area of developing models for atmospheric correction of Nimbus-7 Coastal Zone Color Scanner (CZCS) data to retrieve the phytoplankton pigment. Apart from the CZCS sensor, which is optimised for ocean colour sensing, efforts were also made in the use of Landsat satellite data, which is basically designed for earth resources survey, for fish resources survey.

It is hoped that a long term plan, mutually worked out by all agencies concerned with Marine Resources Survey, will evolve out of these efforts.

Praful D. Bhavsar
Director, IRS-Utilisation Programme
and Associate Director,
Space Applications Centre, ISRO
Ahmedabad

April 11, 1985

Preface

The seminar proceedings on the role of Remote Sensing in Marine Resources is the outcome of the collaborative efforts between Indian Space Research Organisation, Indian Council of Agricultural Research and Ministry of Agriculture, as one of the projects under Joint Experiment Programme (JEP) (1979-1984). The objectives of this programme were to address the spaceborne sensor requirements under Indian Remote Sensing Programme for the application of detection and mapping locations of marine living resources and also to develop methodologies for the extraction of information related to marine living resources survey from remotely sensed data.

Seminar proceedings in all contain nine papers. These papers essentially cover the following topics in terms of our understanding about the role of remote sensing in marine resources survey:-

1. Biological productivity of the Indian Ocean, developments in fisheries technology and scope of remote sensing techniques in marine fish resources survey.

2. Methods in estimating the optical parameters and their relationship with oceanic/biological parameters.

3. Ocean colour mapping from airborne and spaceborne sensors

There are three overview papers which cover a detailed discussion on biological productivity of the Indian Ocean, role of remote sensing in fish resources survey and the scope of Indian Remote Sensing Programme in marine living resources. A detailed understanding of optical processes in remote sensing of ocean colour, relationship between optical and oceanic/biological parameters has been brought out using sea truth data collected during the period preceding South West monsoon i.e. October, November and December 1981 and November 1982 in oceanic waters off Cochin. This area is well known for the occurrence and abundance of pelagic shoals of **oil sardine** and **mackerel.** Role of airborne sensors and spaceborne sensors on **Landsat** and **Nimbus-7** satellites, have been discussed in detail towards extraction of information related to fish resources survey.

We are extremely grateful to Director, Space Applications Centre (SAC/ISRO) and Director General, Indian Council of Agricultural Research (ICAR) for their keen interest and support to this programme. Thanks are due to Shri D.S. Kamat, the then Programme Manager, JEP., Prof. P.D. Bhavsar, Associate Director, SAC and Chairman, RSA, SAC and Dr. Baldev Sahai, Associate Director, IRS-Utilisation Programme and Head, Aerial Surveys Ground Truth and Photointerpretation Division, SAC for their guidance and encouragement. Our sincere thanks to colleagues at SAC, Mrs. V. Sudha, Dr. M.B. Potdar and Dr. P.C. Pandey for their support extended to us in many ways. Thanks are also due to Assistant Director of Cochin base, Fishery Survey of India (FSI), Skippers and crew members of **Meena Sachatak, Meena Utpadak** (FSI Vessels), **Cadalmin I & IX** (CMFRI Vessels). NRSA's flight crew and ground truth team's efforts are also thankfully acknowledged. We would like to thank Shri K.H. Bharadiya and Shri R.V. Nair for drawings, Shri K.M. Bhavsar for photographic support and Shri Naresh Bhatnagar for secretarial assistance.

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A.K.S. Gopalan
Space Applications Centre
Ahmedabad

E.G.Silas
Central Marine Fisheries
Research Institute
Cochin

K.M. Joseph
Ministry of Agriculture
New Delhi

Contents

1.	Biological productivity of the Indian Ocean E G Silas, P V R Nair, P P Pillai, G Subbaraju, V K Pillai and V K Balchandran	1-1-1	1-1-3
2.	Marine fishery resources survey and role of satellite remote sensing in the assessment of pelagic fishery resources in India K M Joseph and V S Somvanshi	1-2-1	1-2-14
3.	Scope of Indian Remote Sensing Programme in Marine living resources survey A K S Gopalan and A Narain	1-3-1	1-3-4
4.	Optical processes in remote sensing of ocean colour A Narain and R M Dwivedi	2-1	2-9
5.	Sea truth data collection: Estimation of diffuse attenuation coefficient in ocean colour mapping Beena Kumari, R M Dwivedi, A Narain, G Subbaraju, P V R Nair and E G Silas	3-1	3-12
6.	Oceanographic parameters and their relationship to fish catch estimation: A case study in coastal waters North of Cochin during 1981 R N Jadhav, A Narain, P V R Nair, V K Pillai, A G Ponnaiah, V K Balchandran, G Subbaraju, E G Silas, V S Somvanshi and K M Joseph	4-1	4-12
7.	Remote sensing of ocean colour and targeting of fish schools from airborne sensors A Narain, R N Jadhav, K L Majumder, G P Sharma, K M Joseph, V S Somvanshi, E G Silas, P V R Nair, G Subbaraju, V K Pillai, A G Ponnaiah and V K Balachandran	5-1	5-8
8.	Application of Landsat MSS data in ocean colour sensing Neera Chaturvedi, Manab Chakroborty, A Narain, G Subbaraju, P V R Nair, E G Silas, V S Somvanshi and K M Joseph	6-1	6-10
9.	Phytoplankton pigment mapping from Nimbus-7 CZCS data R M Dwivedi, Beena Kumari and A Narain	7-1	7-13

OCEANOGRAPHIC PARAMETERS AND THEIR RELATIONSHIP TO FISH CATCH ESTIMATION: A CASE STUDY IN COASTAL WATERS NORTH OF COCHIN DURING 1981

R.N. Jadhav, A. Narain

Space Applications Centre
Ahmedabad 380 053

P.V.R. Nair, V.K. Pillai, A.G. Ponnaiah, V.K. Balchandran G. Subbaraju, E.G. Silas

Central Marine Fisheries Research Institute
Cochin 682 018

V.S. Somvanshi and K.M. Joseph

Fishery Survey of India
Bombay 400 001

Abstract

*Coastal waters in the North of Cochin was selected for the present study. This area is well known for the occurrence and abundance of fish schools of oil sardine (**Sardinella longiceps**) and mackerel (**Rastrelliger kanagurta**) following the period after SW monsoon in the Indian Ocean. Oceanographic data on parameters like, chlorophyll-a, particulate matter, dissolved oxygen, temperature and salinity was collected during October, November and December, 1981 at various ocean depths to look into spatial and temporal aspects. Since the colour of the ocean in terms of chlorophyll-a (present in phytoplankton) provides an useful input about the primary productivity, an attempt was made at relating it with the third level productivity i.e. fish in the ocean food chain.*

Introduction

In the Indian Ocean, hydrobiologically speaking two distinct periods, 'May-October and 'November-April' are identified. These periods are essentially linked to the surface current changes which reverse every half yearly. The surface currents developed during the SW monsoon (May-October) are known to be much more pronounced than those of the NE monsoon (November-April) and lead to pronounced upwellings. In the Indian Ocean such areas are known to form off Somali coast, whereas weak upwellings have been reported in the Arabian sea and the Bay of Bengal. During the International Indian Ocean Expedition (IIOE) for the period 1959-65, extensive chlorophyll-a pigment estimates were made along with the primary production measurements. A strong relationship between the pigment and primary production has been observed in many areas of the sea especially in regions of nutrient enrichment like Northern Arabian sea, West coast of Africa etc. In the near shore waters of the west coast of India on an average a rate of exceeding 1 g c/m^2/day has been observed within 50m depth from the coast. It has been estimated that 1 g c/m^2/day would ultimately provide about 105 kg of both ground fish and pelagic fish (proportion of ground to pelagic fish in general is 30 per cent and 70 per cent respectively) (Prasad and Nair 1971). In order to understand and follow-up the changes in oceanic parameters viz., physical (temperature, salinity), chemical (dissolved oxygen), optical (Secchi disc depth), biological (chlorophyll-a, particulate matter) and fish catch (for the period 1977-81), a group of four research/fisheries vessels were deployed in the coastal waters over North of Cochin during October, November and December 1981.

Data Acquisition

Figure 1 shows the study area located North of Cochin Coast and vessel positions with respect to station depth viz., 10, 20, 30, 40 and 50 meters. The first sampling station was located at 10m depth in order to avoid the areas which are under active influence of land runoff and river discharge. The sampling station lie between 3 km (10m station) and 39 km (50m station). This roughly covers the waters in which most of the biological productivity takes place.

Oceanic Parameters

Data about various parameters, such as physical (temperature, salinity), chemical (dissolved oxygen), optical (Secchi disc depth, ocean colour - Forel-Ule colour scale) and biological (chlorophyll-a, particulate matter), was collected at station depths of 10, 20, 30, 40 and 50m. Oceanic parameters were estimated from water samples collected from 0 (surface),1 and 6m's. All water samples were collected with Nansen reversing bottles. Water samples were poured into 2-3 litre polyethylene screw-cap bottles. Samples for pigment estimations were kept in cool dark place. Various oceanographic parameters were estimated as per methods described in Barnes (1959) and as in Strickland and Parsons (1965 and 1968).

Oceanic parameters were analysed on samples collected from 0 (surface), 1 and 6 meters. There were two large vessels (17.5 m overall length - OAL) denoted as V1 (Meena Sachatak), V2 (meena Utpadak) and two small vessels (14.3m OAL) V3 (Cadalmin I) and V4 (Cadalmin IX). Vessel positions were kept same in all the threetime surveys.

Fish Catch Data

Two identical fishing vessels (17.5 OAL, 2000 BHP and 56.5 GRT) were deployed from Cochin to cover the coastal waters North of Cochin. These vessels were stern trawlers having six days endurance. Both the vessels were with Simrad echo-sounder for locating the ground for trawling, detection of fish school concentration and recording depth. The fish concentration and trawlable sea bed thus selected was sampled by 24m fish trawl. In order to get required horizontal opening, oval otter boards, each weighing 180 kg, were used. The net was towed in the areas having desired depth for two hours with an average trawling speed of 2.5 Knots. However, on certain occasions the fixed two hours sampling period could not be adhered to, due to the uneven nature of the sea bed, under water obstacles, catch etc. The information on fishery resources included details like catch (quantity) and its distribution with respect to area and depth belts.

Data Analysis

Oceanic Parameters

Oceanic parameters viz., chlorophyll-a (mg m^{-3}), particulate organic matter (mg/1), dissolved oxygen (ml/l), temperature (°C) and salinity (‰) was estimated /analysed from water samples collected at various stations depths and sampling depths.

Fish Catch Data

Figure 2 shows the typical index map used for plotting the fish catch data. Each degree of latitude is divided into six sections of 10 nm each and given numeric codes viz., 1,2,3,4,5 and 6 (sequenced in northward direction). Similarly each degree of longitude is divided into six sections of 10 nm each and given alpha codes viz., A,B,C,D,E and F (sequenced in eastward direction). Each grid of 10 nm x 10 nm is then referred to as sub-area. These sub-areas of 10 nm x 10 nm are with respect to the major areas by giving the co-ordinates viz., longitude and latitude for example 10 (lat.) - 76 (long.) - 1A (sub-area) etc.

Data on catch rate (kg/hr) of total fin-fish as explored by the survey vessels during 1977-81 was analysed depth-wise and presented for October, November and December (Figure 3). In the present analysis only some portions of major areas 10-75 (3E, 1F, 2F and 3F) and 10-76 (1A, 2A) were considered as these fall well within the study area. The sub-areas viz., 3E, 1F, 2F and 3F of the major areas 10-75 and 1A, 2A of 10-76 were sampled for fish abundance. The catch data was transferred on the map with respect to 10m depth interval for all the sub-areas surveyed to show the fish density (Catch, kg/hr). Above data was plotted so as to compare it with data of other oceanic parameters as mentioned earlier.

Results and Discussions

Oceanic Parameters

Figure 4 (a,b,c and d) show the data plotted for various oceanic parameters with respect to station depths viz., 10,20,30,40 and 50m for different months. Apart from chlorophyll-a, particulate matter, and Secchi disc depth, there was no significant change in other oceanic parameters viz., dissolved oxygen, temperature and salinity. This indicates that the hydrographic conditions had more or less stabilised. Figure 4a, b, c and d show the oceanographic data plotted for October, November and December which was collected for station depths viz., 10,20,30,40 and 50m. In general, it can be seen that in all the three time data an inverse relationship was observed between Secchi disc depth and chlorophyll-a (pigment) concentration (Figure 4a,b & c). The pigment shows a gradual decrease with increasing depth. Particulate matter also shows a somewhat similar pattern. Table 1, 2 and 3 show the data for various oceanographic parameters along with their standard deviation for October, November and December, 1981. During October on an average a high pigment value of about 4.8 mg m^{-3} was observed at 10 m station depth followed by a low value of about 1.4 mg m^{-3} at 50 m station depth. Similarly during November and December, the maximum value of about 2.4 mg m^{-3} and 3.3 mg m^{-3} respectively was observed at 10m followed by 0.48 and 0.96 at 50 m respectively. The magnitude of change in particulate matter (expressed as mg/l) was maximum in December between 10m and 20m station depths. In general it is seen that particulate matter also shows an inverse relationship with Secchi disc depth. Also that particulate matter shows a similar pattern i.e. it decreases with increase in station depths from 10 m to 50 m. During November data on oceanic parameters other than chlorophyll, Secchi disc depth, particulate matter could not be colleted for 50 m and similarly for December data on oceanic parameters could not be collected for 40 m depth. It is clear that apart from studying the variations in oceanographic parameters from month to month it is very important to relate these variations with respect to station depth. This helps in understanding the changes which are taking place not only in time but also in space. Using two seasons (1966 and 1967) data off Cochin during International Indian Ocean Expedition - IIOE (1959-65), Shah (1973) has shown that two distinct periods "May-October" and "November-April" are observed. He concluded that the annual variations in oceanographic parameters like chlorophyll-a, salinity, temperature, oxygen etc show a pattern which repeats year after year. Apart

Table 1

Sea truth data on oceanic parameters and their standard deviation for October 22-24, 1981

Station depth (m)	Oceanic Parameters					
	Chlorophyll-a (mg m^{-3})	Secchi disc depth (m)	Salinity (‰)	Temperature (°C)	Dissolved oxygen (ml/l)	Particulate matter (mg/l)
10	4.79±1.35	3.0±0.50	30.33±1.32	28.6±0.53	4.7±0.16	24.4±3.74
20	3.49±2.25	4.00±0.50	31.33±2.26	28.9±0.28	5.0±0.55	22.40±3.68
30	2.72±1.06	6.5±2.0	31.29±0.31	29.3±0.32	5.0±0.42	25.50±2.8
40	1.60±0.21	15.5±1.00	34.12 -	29.0 -	5.37 -	20.48±0.93
50	1.39±0.78	16.0±1.00	34.3±0.16	29.5±0.20	5.30±0.22	19.88±2.62

Table 2

Sea truth data on oceanic parameters and their standard deviation for November 27, 1981

Station depth (m)	Oceanic Parameters					
	Chlorophyll-a (mg m^{-3})	Secchi disc depth (m)	Salinity (‰)	Temperature (°C)	Dissolved oxygen (ml/l)	Particulate matter (mg/l)
10	2.42±0.65	6.0±2.0	30.53±0.16	28.9±0.05	4.01±0.08	14.01±1.24
20	0.96±0.34	15.5±1.00	30.35±0.21	28.6±0.20	4.0±0.09	14.33±1.00
30	1.15±0.32	15.0±1.0	30.89±0.25	28.72±0.09	4.08±0.09	12.44±1.19
40	0.24 -	20.1 -	29.61 -	28.7 -	-	17.40 -
50	0.48 -	20.5 -	-	-	-	-

from above observations it was seen in the present study that information about the ocean water and its constituents could easily be obtained by using simple devices like Forel-Ule colour scale (a colour comparator) and Secchi disc. Figure 5 shows that there is a clear-cut increase in ocean transparency and changes in ocean colour (essentially linked to a decrease in its constituents with time).

Fish Catch Data

The total fin-fish catch rate (kg/hr) data pooled for the period 1977-81 and corresponding to October, November and December is presented in Table 4.

Table 3

Sea truth data on oceanic parameters and their standard deviation for December 15, 16, 1981

Station depth (m)	Oceanic Parameters					
	Chlorophyll-a (mg m^{-3})	Secchi disc depth (m)	Salinity (‰)	Temperature (°C)	Dissolved oxygen (ml/l)	Particulate matter (mg/l)
10	3.32±0.76	1.5±0.50	32.60±0.07	28.8±0.52	4.00±0.25	24.05±6.39
20	0.94±0.70	5.5±1.00	32.71±0.58	28.7±0.15	4.40±0.17	17.00±6.25
30	0.63±0.43	17.00±3.00	32.40±0.31	28.6±0.15	4.70±0.27	17.1±7.3
50	0.96 -	15.5 -	32.40 -	29.0 -	4.83 -	15.1 -

Table 4

Fish catch data for October, November and December (1977-81)

Month	Catch rate	± S.e.e.*
October	83.1	±10.5
November	57.3	±11.6
December	44.7	±6.2

* Standard error of estimate

The fish catch data shows a gradual decrease with time. A plot for fish catch and pigment concentration shows a non-linear relationship (Figure 6). This follows a characteristic S-shaped growth curve. There is an initial period of slow growth which eventually stabilizes below a certain ceiling level. The term growth used here is in relation to exchange between primary producer and secondary consumer in ocean food chain. At a certain level, it is observed that although there is a marginal increase in the pigment the fish catch shows an almost two-fold increase.

Conclusions

A follow-up of changes in oceanographic parameters with respect to station depth helps in understanding their pattern in time and space. This data will provide a useful input while using in conjunction with remotely sensed data from aircraft or orbital platforms, where such a requirement becomes a prerequisite.

Data about the ocean water and its constituents could be easily obtained by using simple devices like Forel-Ule and Secchi disc. An attempt has been successfully made in relating the fish catch with pigment concentration.

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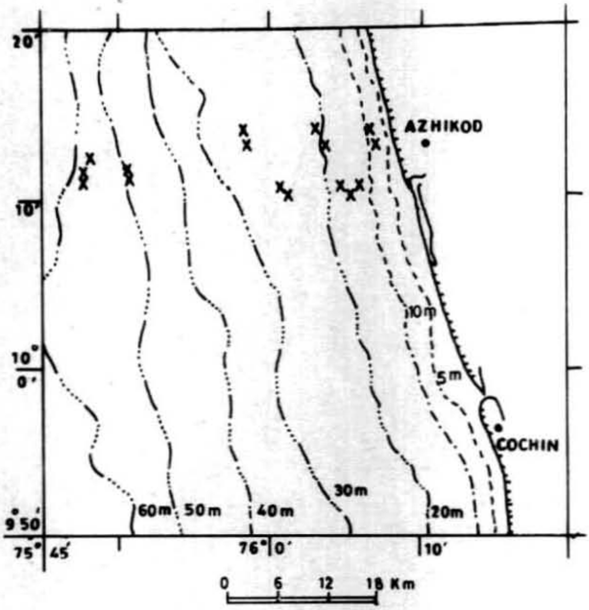


LEGEND

NAME OF THE VESSEL	VESSEL CODE	OPERATING DEPTH (m)	RUN NO
MEENA SACHATAK	V_1	40,50	7, 8
MEENA UTPADAK	V_2	10, 30,50	5
CADALMIN I	V_3	10,20, 30	1, 3
CADALMIN IX	V_4	10,20,30	9,10

Fig. 1 Study area showing vessel position (X) with respect to operating depth (m)

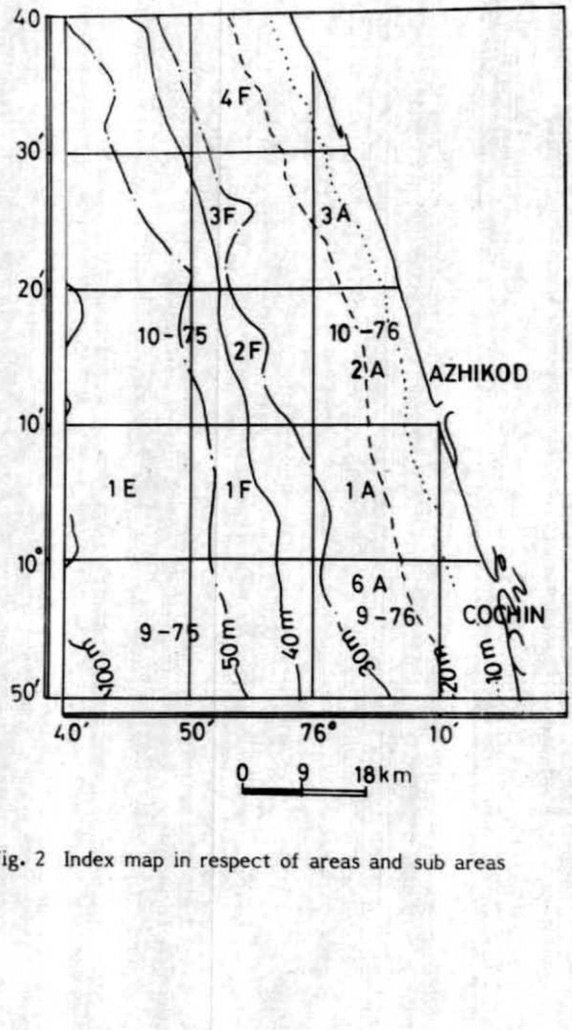


Fig. 2 Index map in respect of areas and sub areas

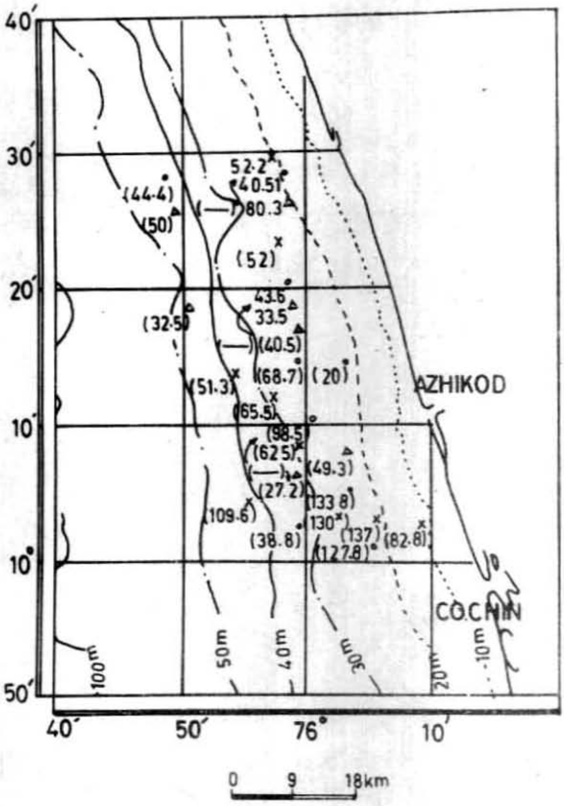
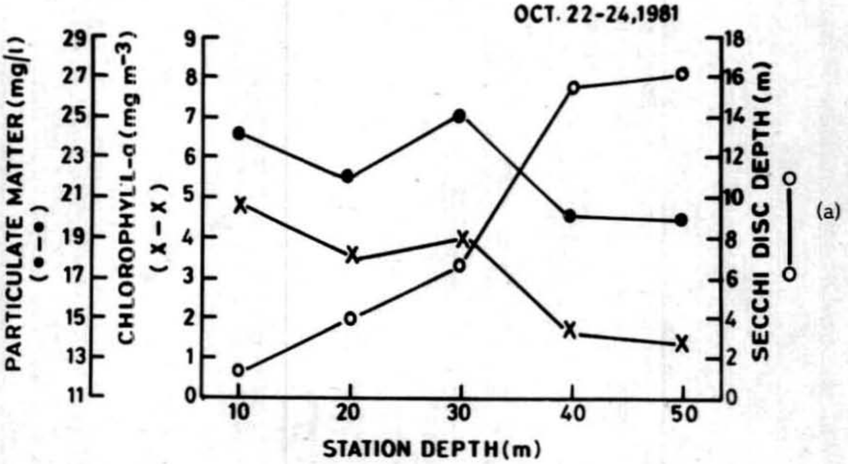


Fig. 3 Fish catch rate (kg/hr) data for October (X), November (0) and December (Δ) (1977-81)



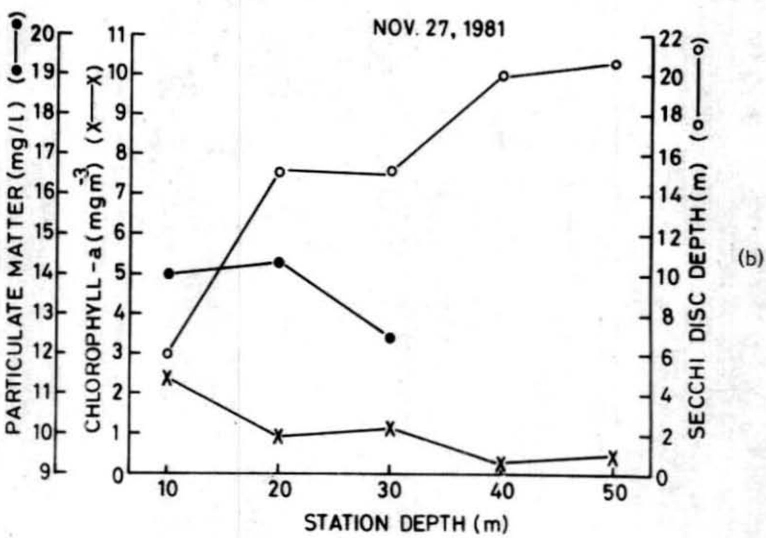
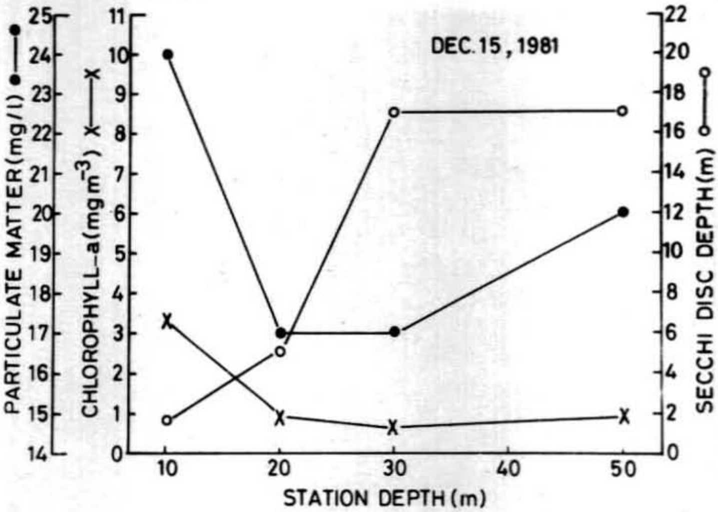
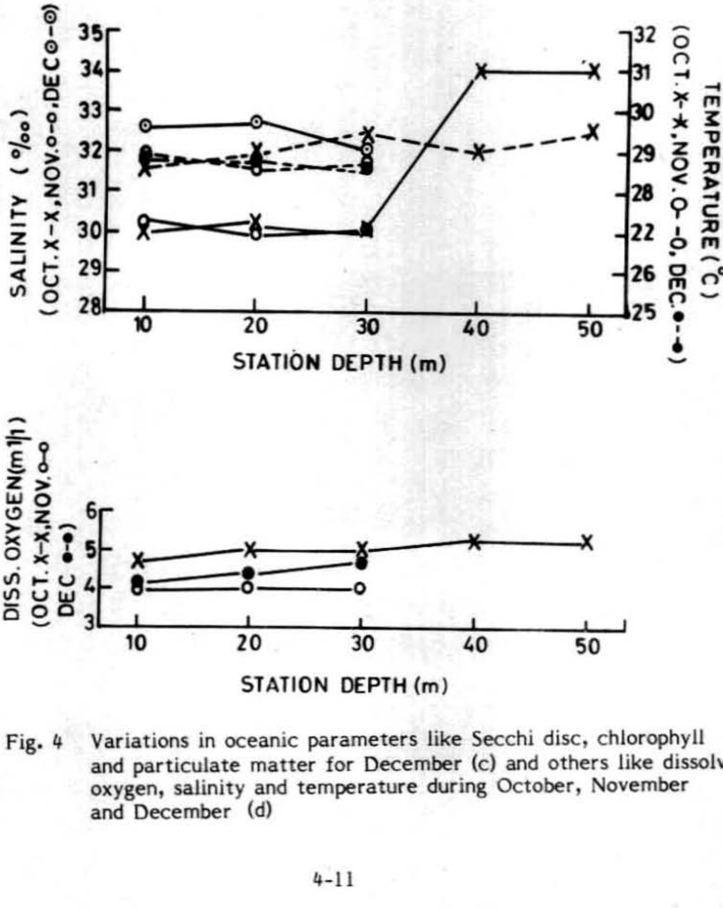


Fig. 4 Variations in oceanic parameters for October (a) and November (b)



(c)



(d)

Fig. 4 Variations in oceanic parameters like Secchi disc, chlorophyll and particulate matter for December (c) and others like dissolved oxygen, salinity and temperature during October, November and December (d)

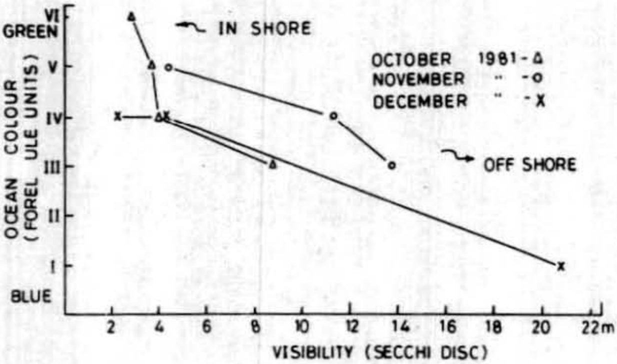


Fig. 5 Ocean colour (Forel-Ule colour scale) versus Secchi disc depth

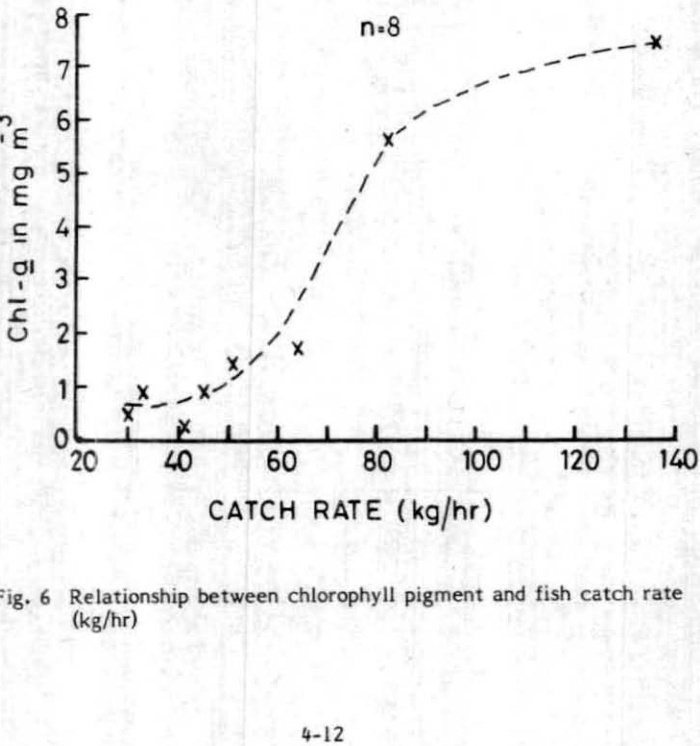


Fig. 6 Relationship between chlorophyll pigment and fish catch rate (kg/hr)