# BIOLOGY OF DECAPOD CRUSTACEANS IN DIFFERENT ENVIRONMENTAL CONDITIONS

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# DECLARATION

I hereby declare that the data provided in the thesis were not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar title of recognition in any University or Institution.

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## CERTIFICATE

This is to certify that this thesis is an authentic record of the work carried out by Shri.K.V. Devasia, M.Sc., under my supervision, in the School of Environmental Studies of the University of Cochin and that no part thereof has been presented before for any other degree in any University.

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## CONTENTS



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# PREFACE

Coastal zones hold maximum population throughout the world. A coastal civilization of global nature which is unique in their food habits namely fish eaters have emerged from time immemorial. It is not surprising to note that details of different organisms in coastal and nearshore waters were well known even before the development of modern science. In the past, exploitation of resources never exceeded the recruitment level and except for natural calamities there was no dearth of food. But of late man started to share the aquatic resource with his companion living in the remote areas of the world. To meet this, various technologies were developed for fishing, processing and transporting. All these activities had a decided impact on the coastal fisheries which became exhausted or nearly depleted. When natural resources were dwindling at rates faster than they could be renewed, man has started alternate methods for improving fishery resources. Various technologies and techniques were evolved for aquaculture whereby favoured groups such as prawns, lobsters, crabs, bivalves and various finfishes could be stocked and reared.

India has a potential coastline of 6100 km. Many maritime states have adopted the technologies developed indigenously to culture prawns and other shell fishes.

In order to have successful aquaculture programme a thorough knowledge of the ecology, biology, physiology and systematics of the organisms concerned is a prerequisite.

The traditional prawn culture in the brackish water lagoons and paddy fields of Kerala are well known. But scientific data on the dynamics of feeding and growth as well as the ecology is meagre.

Of late setbacks have been noticed in the traditional method of aquaculture for penaeid prawns. This could be attributed to the changes in water quality, consequent on the effluent discharges from the complex industrial concerns situated in the neighbourhood of watercourses which feed the culture fields. In order to have better and sustained yields it is necessary that traditional methods are suitably modified. This calls for a detailed study of the ecosystem and the ecology and bionomics of the organisms to be cultured. Alternate methods for increasing production is to be identified and more organisms are to be included in the purview of aquaculture.

The present investigations are carried out with this intention. An examination of the Crustacean fishery prevailing along the coastal and brackish-water systems of Kerala reveals that attention was given only to the penaeid prawn fishery. No organised attempt is made to improve the crab fishery which has a potential fishery status in Kerala waters. During the present investigation, biology and ecology of the crab *Scylla serrata* Forskal and the prawn *Penaeus indicus* H. M. Edwards were undertaken.

In the first part of the thesis, the state of the environment of Cochin backwater is discussed. This is followed by the results of the studies on the hydrography of Cochin backwaters. Later Chapters are devoted to the investigations on various aspects of *S. serrata* in the backwater like its fishery, food and feeding habits, reproduction and length weight relationship and condition factor. The second part deals with the studies on the environmental characteristics of prawn culture fields, benthic production and food and feeding habits and growth and condition factor of *P. indicus*.

# P A R T I

## INVESTIGATION ON THE CRAB

## *SCYLLA SERRATA* (FORSKAL)

THE CRAB *SCYLLA SERRATA* (FORSKAL)

# CHAPTER-I

## INTRODUCTION

Among the invertebrate phyla, phylum Arthropoda is the largest comprising as many as one million species. Decapoda is an order under the class Crustacea of the phylum Arthropoda and includes the highly esteemed food organisms like prawns, lobsters and crabs. Because of their significance as a high priced, delicious and protein rich food with much export potential, investigations on the ecology, fishery, biology, physiology and bio-chemistry are carried out in various parts of the world, to augment the production of these organisms through aquaculture.

Decapod Crustaceans occupy a wide range of habitats like the terrestrial, fresh water, estuarine and marine. They are very well adapted to the environmental conditions in which they live. These adaptations involve modifications in the morphology, anatomy and physiology of the organisms.

Among Decapod Crustaceans, true crabs are the most fascinating animals and are of abiding interest not only to the scientists but even to the layman. Crabs are organisms with broad and hard carapace, which are brilliantly coloured and ornamentally sculptured in some cases, with massive chelate legs which are incrediably strong and unbelievably disproportionate in some species and with a bent abdomen. The various modes of life like the terrestrial, intertidal, benthic and burrowing are of immense interest to the ecologists and the ability of these organisms to adapt to a multitude of environs are of inquisitive interests to the physiologists. The breeding habits, life history, commensalism with other invertebrates, all have attracted many a biologists and enabled them to carry out substantial work on the various biological aspects of these organisms.

Along the west coast of India, Cochin backwaters supports a good fishery of Portunid crabs. Crab fishery in Cochin backwaters is mostly a single species fishery. The estuarine crab Scylla serrata (Forskal) is the one fished in sizable quantities from these waters. Other species caught include Portunus pelagicus (Linnaeus) and P. Sanguinolentus (Herbst). Scylla serrata serrata is also noticed in the catches but it does not contribute much to the fishery. Charybdis cruciata (Herbst) is seen occasionally in the catches, but only during summer months when the salinity is high.

Though a potential one, the fishery of the crab S. serrata is a highly neglected one in Cochin backwaters. Except the report by Pillai and Nair (1973), practically no work was done on various aspects of the fishery of this crab, which if properly managed can be developed into a lucrative one.

*S. serrata* is a potential species for brackish-water culture. Only method to augment the production to a substantial level is by resorting to culture. But before starting culture, a thorough knowledge about the environmental requirements of the animal, life history, breeding habits, growth rate, diseases etc. are inevitable. The present work is aimed at investigating the various biological aspects of *S. serrata* like growth, food and feeding habits and breeding in relation to the various environmental parameters. The craft and gear employed for fishing and various management problems of the fishery are also dealt with. Some suggestions are also made for the improvement of the fishery.

## REVIEW OF THE PREVIOUS WORK

A review of the scientific investigations on commercially important decapod crustaceans reveals that most of the work is concentrated on shrimps and prawns - evidently because of their attractive market price, high demand and esteemed nutritional value - and comparatively less work is done on various aspects of crabs. Again, a critical scrutiny of the various works done on different species of crabs shows that more work is done on breeding biology, larval development, biochemical aspects and only less work is done on growth, food and feeding, pollution and related aspects. In the present review, an attempt is made to refer to the significant works done by various workers on different species in various parts of the world. Some of the notable works are those of Stead (1898) on Neptunus, Williamson (1900, 1904) on Cancer pagurus, Meek (1903, 1904, 1905 1907, 1913, 1914) on crabs of Northumberland, Hiat (1948) on Pachygrapsus crassipes, Kenneth (1958) on Cancer magister, Scattergood and Leslie (1952) on Cancer maenas. Classical works done in recent years are those of Von Engel (1958, 1962) on the blue crab fishery of Chesapeak Bay,of Rees (1963) on the edible crabs of U.S.A., Tagatz (1965) on the blue crab fishery in St. John's river, Florida, Edwards (1962, 1964, 1965a, 1965b, 1966a, 1966b, 1966c, 1967, 1971) on Yorkshire crab, European edible crab and Norfolk crabs, Turoboyski (1973) on Rhithropanopeus harissi in Japanese waters, Lewis (1975) on Bathynectes superrbus in Chesapeake waters, Hill (1975) on S. serrata from South African estuaries, Yang et al. (1979) on portunid crabs of China and Ingel (1980) on British crabs.

BREEDING BIOLOGY

Scientists from various parts of the world have done considerable work on the breeding habits and reproductive systems of different species of crabs. Quite a lot of investigations are also made on the histological and biochemical aspects during development.

Some of the earliest records on breeding biology and larval stages of crabs are that of Cunningham (1898) on the early post larval stages of *Cancer pagurus*. A generalised account of the reproductive system of *C. pagurus* is given by Williamson (1904) and Pearson (1908). Oogensis and fertilisation on the stone crab *Menippe mercenaria* are described by Binford (1913). Fasten (1915, 1917, 1918, 1926) has contributed a number of papers on the male reproductive system and on spermatogenesis in several species of crabs. Churchill's (1919, 1942) work throws light on the breeding and life history of blue crab. Labour (1927, 1928, 1928a, 1944) has investigated the larval stages of different species of crabs. Studies by many workers on the European portunid crabs, *C. maenas* have contributed much to the knowledge of the intricacies of the female reproductive system. Notable among these are the works of Harvey (1929), Shen (1935), Brockhuysen (1936), Spalding (1942) and Demeusy (1958). Hard (1942) described some of the histological changes in the ovary associated with ovulation in *Callinectes*. Cronin (1942, 1947) studied the histological development of the ovary and accessory organs and the anatomical and histological development of the male reproductive system of the important American species, *Callinectes sapidus* in late juvenile stages. Again, Hopkins (1943, 1944) described the external morphology of the zoeal stages of the above species. Oogenesis is described for several species of the portunid genus, *Scylla*, by Estampador (1949). Studies on the periodic changes in the reproductive cycle of several species of arthropods are conducted by Boolootian *et al*. (1959) and Giese (1956). Butler (1960) has given an account of the maturity and breeding of the Pacific edible crabs *Cancer magister* Dana. Courtship behaviour of the lined shore crab, *Pachygrapsus crassipes* is studied by Bovbjerg (1960). A good account of the reproduction, reproductive cycles and mating process of crabs are given by Kundsen (1960, 1964 a, 1964 b). The mating behaviour of the Japanese crab, *Macrocheira kaempferi* is investigated by Arakawa (1964). Powell and Nickerson (1965) have described the reproduction of the king crab, *Paralithodes camtschatica*, Gray and Powell (1966) have given an account of the ratio and distribution of spawning king crabs. Cheung (1966) gave a note of copulation in *Carcinus maenas*. Nielsen (1966) has investigated and reported the premating and mating behavior of *Cancer magister*.

No detailed study of the anatomy, histology and physiology of the female reproductive system in any brachyura was done until 1967 when Ryan (1967) made a thorough investigation of the structure and function of the female reproductive system in *Portunus sanguinolentus*. Ryan (1967 a, 1967 b) also studied the morphology, morphometry and mature instars and the male reproductive system of P. sanguinolentus. A detailed description of mating in brachyura is provided by Hartinoll (1968). Some other noteworthy works on various aspects of the breeding biology are those of Haley (1967, 1969, 1973) on the texas ghost crabs, Ocypode albicans, O. quadrata and O. caratopthalamus, of Hinsch (1968,1970, 1972) in Libini emarginata, of Watson (1970) on spider crab Chionocoetes opilo and of Fielder and Eales (1972) on Portunus pelagicus. Chiba and Honma (1972) observed the gonadal maturity in Pachygrapsus crassipes. Yolk formation in developing oocytes of Cancer pagurus is studied with the aid of electron microscopy by Eurenius (1973). Laulier (1974) classified the maturing ovary of Cancer maenas and Dhainaut and Leersnyder (1976) conducted cytochemical studies on the developing Oocytes of Eriocheir sinensis. Lewis (1977) investigated the sexual maturity of Bathynectes superrbus. Studies on the larval developments of different species of crabs are conducted in the laboratory by Rice and Ingle (1977), Ingle (1979), Terada (1981), and Iwata (1981). Spelkin and Fedoseev (1980) reported spermatogenesis in king crab. Berril and Arsenault (1982) described the mating behaviour of Carcinus maenas.

STUDIES IN INDIAN WATERS

When compared to the work done in other parts of the world, only a little work is done on various aspects of breeding and larval development of crabs in Indian waters. Some of the earlier works are those of Bhatia and Nath (1931), Bhatacharya (1931), Nath (1932, 1938, 1941), Iyer (1933), Rai (1933), Menon (1933, 1937), Chopra (1939) and Panikkar and Iyer (1939). Menon (1952) made a note on the breeding season of Portunus sanguinolentus. Development in Paratelphusa jacquemoutiti is studied by Chacko and Thyagarajan (1952). Prasad and Thampi (1953) investigated the breeding season and early larval stages of Portunus pelagicus. Naidu (1955) has traced the development of the zoea of Scylla serrata and Portunus sanquinolentus. A good account of the breeding habits and larval stages of some crabs of Bombay coast is given by Chhapgar (1956). George and Nayak (1961) have given an account of the breeding and maturing of the crabs of Mangalore coast. The embryology and male and female reproductive system of Portunus sanquinolentus are well studied by George (1963). Krishnaswamy (1967) has given an account of the reproductive and nutritional cycles of a few invertebrates including Portunus pelagicus, from the east coast of India. Rahman (1967) has investigated the reproductive and nutritional cycles of P. pelagicus of Madras coast. Studies on the ovary in

*Paratelphusa hydrodromus* is carried out by Sareen (1969). Adiyodi (1968) has described the role of conjugal proteins during vitellogenesis in *Paratelphusa hydrodromus*, a fresh water crab. In 1968 b, he has studied the reproduction and moulting and later in 1969 b, the RNA activity and biosynthesis of yolk. Again, in 1970, Adiyodi has investigated the lipid metabolism in relation to reproduction and moulting, in the same species. Adiyodi and Adiyodi (1970) studied the endocrine control of reproduction in decapod crustacea. Pillai and Nair (1968, 1971, 1973 a, 1973 b) have given an account of the reproductive cycle, breeding biology and other aspects of a number of crabs of the south-west coast of India. Diwan and Nagabhushanam (1974) observed the variations in biochemical constituents during reproductive cycle in *Barytelphusa cunicularis*. Reproductive cycle of *Clibanarius longitarusus* is studied by Ajmalkhan and Natarajan (1972 a). John and Sivadas (1978, 1979) studied morphological and histological changes in the gonad of *Scylla serrata* after eye stalk ablation. Radhakrishnan (1979) investigated the breeding biology and the cytological, cytochemical and biochemical aspects of ovary matuation of selected crabs of portonovo waters. Ajmalkhan and Natarajan (1981, 1981) reported the reproductive strategy and larval stages of hermit crab.

FOOD AND FEEDING HABITS

Not much work is done on the food and feeding habits of crabs. This is because of the less importance given to the fishery and negligence of exploring the culture potential. As early as 1947, Lunz reported that blue crabs and mud crabs feed upon mussels, hard clam and oysters. In 1948, Turner studied the food of *Callinectes sapides*. Butler (1954) and Menezel and Hopkins (1955) reported the food and feeding habits of various species of crabs. Dunnington (1956) after investigations on blue crabs came to the conclusion that they dig soft shell clams for food. Further studies by Spear and Glude (1957) showed that the blue crab, *Callinectes sapidus* feeds on soft clam, *Mya arenaria*. In 1958, Darnell studied the food habits of some crab in Pontchartrain Lake. Hanks (1963) after further studies on *C. sapidus* came to the same conclusion as Spear and Glude (1957). Ebling *et al.* (1964) reported that some crabs feed on bivalves and Muntz *et al.* (1963) reported the predatory activity of large crabs. Guinot (1966) studied the food of the crabs of Indo-Pacific area. Investigations by Ropes (1968) threw light on the feeding habits of *Carcinus maenas* and Togatz (1968) has analysed the gut contents of *Callinectes sapidus*. Some detailed investigations on the food of portunid crabs were done by Eales (1972) and Walne and Dean (1972) experimented the predatory activity of Carcinus maenas. Caine (1974) reported the feeding habit of Ovalipes quadulpensis. Hamilton (1976) has studied the predatory activity of Callinectes sapidus. Hill (1976) is the first to analyse the natural food of Scylla serrata. MacKenzie (1977), Whetstone and Eversole (1978) and Seed (1980) studied the food and feeding habits of blue crabs and mud crabs. Hughs and Seed (1981) discussed the mode of size selection of mussels by the blue crab, C. sapidus and Paul (1981) investigated the food and feeding habits of C. arcuates and C. toxotes. Blundon and Kennedy (1982, 1982) dealt with various aspects of predation of blue crab C. sapidus.

STUDIES IN INDIAN WATERS

Only isolated reports are available on the food and feeding habits of crabs in Indian waters. This is because even now crab fishery in India is a neglected one. Prasad and Thampi (1953) referred Portunus pelagicus as 'scavengers and cannibals.' They also observed that this crab feeds readily on clam meat, prawns and small fish in the laboratory. Patel et al. (1979) has analysed the stomach contents of P. pelagicus and referred it as bottom feeding in habit.

## GROWTH STUDIES

Studies on age and growth in crabs are sparse and are limited to a few species. In 1923 Olmsted and Baumberger studied the growth of grapsoid crab. Butler (1957) and Mason (1965) used tagging method for growth studies. Sinoda (1968) investigated growth in the crabs of Japanese sea. Several workers have investigated and reported age, and growth of Cancer magister and C. pagurus collected from different areas. The works of Mackay and Weymouth (1935), Cleaver (1949), Butler (1961) and Poole (1967) on growth of crabs are worth mentioning. Investigations on the growth of C. pagurus include those of Mackay (1943), Mistakidis (1959), Edwards (1965, 1966), Hancock and Edwards (1966, 1967), Bennett (1971) and Hill (1975) respectively.

## POLLUTION STUDIES

Investigations on the effect of various environmental factors and other substances on crabs are recent. Rapid degradation of the aquatic environment due to different types of pollutants adversely affected crab fishery. Several workers have investigated the effect of pollutants on the biology of the crabs. Some of these works include the effect of heavy metals, pesticides, oil etc. on the organism. Thus Glickstein (1978) experimented the toxic effect of mercury and selenium and Mirkes et al. (1978) reported the effect of cadmium and mercury on the larvae of crabs. Effect of heavy metals like cadmium and lead on ATP [illegible]ases in the gill of Cancer irroratus is studied by Tucker and Matte (1980). Weis (1978) studied the effect of some metals on the regeneration of the appendages of crabs. Investigation on the thermal shock on Scylla serrata was done by Hammumante et al. (1980). Oil pollution studies on different species are carried out by Cucci and Epifanio (1979), Vandermeulen et al. (1980), Strobel and Brenowitz (1981) and Jackson et al. (1981). Effect of pesticide on crab is reported by Rhead et al. (1981) Cantelmo et al. (1981) experimented the effect of benezene on the moulting of Callinectes sapidus.

## CHAPTER - II

## ENVIRONMENTAL CHARACTERISTICS OF COCHIN BACKWATER

### PRESENT STATE OF THE ENVIRONMENT

Cochin backwaters (Lat. 9°28' and 10°N and Long. 76°13' and 76°31') is the longest among Kerala backwaters and extends from Crangannore in the north to Alleppey in the South (Fig.1). It consists of a system of inter-connected lagoons, swamps and mangrove biotopes. The northern portion of Cochin backwater is called Varapuzha lake and the southern portion is termed as the Vembanad lake. The backwater system has a total length of about 110 Kms. and a maximum width of 15 Kms. (average 3.2 Kms.) and covers an area of 256 sq. Km. During the pre-Christian era, this backwater system appears to have been cordoned off from the sea by a narrow strip of land, lying south of Munambam and north of Quilon, formed by the interaction of detritus loaded river water and the ocean ground swell (Bristow, 1959). It opens into the Lakshadweep Sea at Cochin and Munambam, about 18 Kms. north of Cochin. Since 1928, the opening at Cochin is periodically dredged to maintain sufficient depth for navigational purpose while the other remains undisturbed.

According to Pritchard (1967) 'An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water

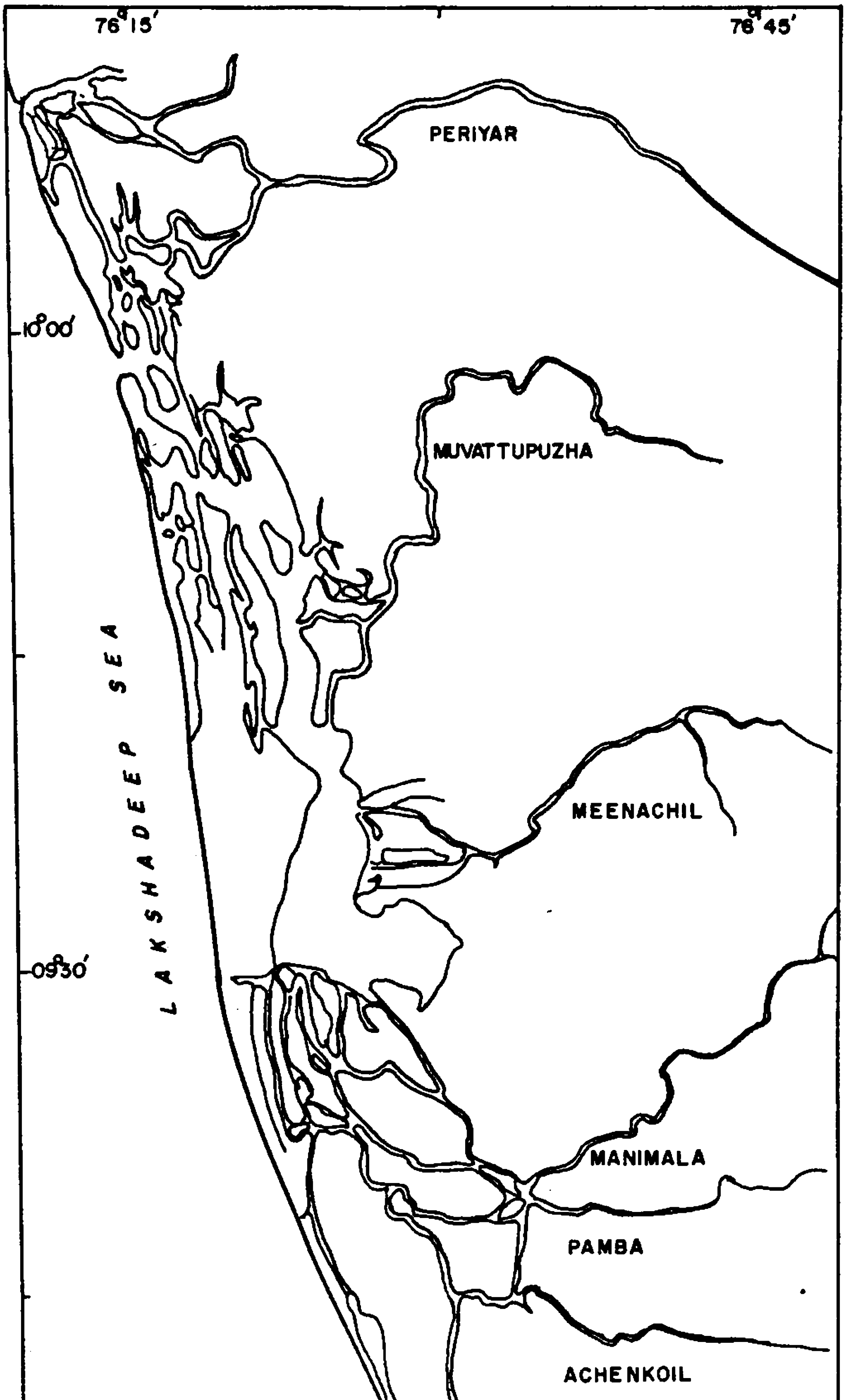



Fig. 1 COCHIN BACKWATER SYSTEM

is measurably diluted with fresh water derived from land drainage." As per this definition, this back-water system can be considered as an estuary because the fresh water discharge from the rivers and land run off make the backwater a typical estuary. The run off plus precipitation exceeds evaporation and hence it is a positive type estuary (Balakrishnan, 1957). Thus in the following discussions both the terms backwater and estuary are used.

In Cochin backwaters, the tides are of a mixed semidiurnal type, the maximum range being about 1 m. With the increase in distance towards the upper reaches of the estuary the magnitude of its influence progressively decreases as the time lag in the tidal height increases and the tidal range decreases (Quasim and Gopinathan, 1969) The physico-chemical properties of estuarine waters vary considerably. They depend on volume and contents of the river water released, structural components of the estuarine bed, tides and macroclimate of the general geographic area (Kinne, 1966). A number of rivers originating from the western ghat flow into the backwaters at various points. Five rivers, viz., Achancoil, Pamba, Manimala, Meenachil and Moovattupuzha with its tributory Ithypuzha meet the backwaters south of Cochin while two rivers viz., Periyar and Chalakudy meet it north of Cochin. These rivers bring in huge quantities of fresh water into the backwaters during the south-west and north-east monsoon.

The backwater system undergoes remarkable seasonal changes which is reflected by considerable changes in its various physico-chemical characteristics during different seasons of the year. A number of workers who studied the various hydrographic parametres have reported three definite seasons viz., pre-monsoon, monsoon and post-monsoon based on the environmental parameters existing in the backwaters during these periods (Sankanarayanan and Quasim, 1969; Haridas et al. 1973; Joseph, 1974; Manikoth and Salih, 1974; and Balakrishnan and Shynamma, 1976)

The seasonal changes in environmental characteristics influence the flora and fauna of the backwaters. Carikkar (1967) classified estuarine organisms as (a) oligohaline organisms (b) true estuarine organisms (c) euryhalive organisms, (d) stenohaline organisms and (e) migrants. During the dry months, the estuary forms a conducive habitat for marine organisms while during monsoon period it satiates the physiological needs of freshwater organisms. Besides these marine and fresh water organisms that occupy the estuary during different seasons of the year, there are numerous true estuarine organisms with the physiological capacity to adapt to highly changing environmental parameters.

Numerous studies carried out in various parts of the world throws much light on the significance of estuaries as a separate entity. It is inevitable for the successful completion of the life history of several organisms. It forms the nursery of a multitude of shellfishes and fin fishes. Estuaries, as a rule, are biologically more productive than the adjoining bodies of fresh water and sea water (Abbott et al. 1971). Productivity studies carried out by various workers in the Cochin backwaters have showed that this water body is a highly productive one. Gopinathan (1972) reported 120 species of phytoplanktons commonly occurring in this backwaters with two peaks of abundance, one during monsoon (May-July) and the other during post-monsoon (October-December). Nair et. al. (1975) using $C^{14}$ technique estimated the total annual production for Cochin backwaters as 100,000 tons of carbon. The average annual rate of gross production ranged from 150 to 650 g $C/m^2$/yr. at different regions. Unlike in the inshore regions of the west coast where maximum production occurs during monsoon periods, in the Cochin estuary relatively higher rate of production is observed during the pre and post-monsoon periods. Of the gross production, 20-45 are considered to be used for respiration and of the net production available to the next trophic level, only a very small portion (30 g C/$m^2$/yr) is used by zooplankters leaving a large surplus of basic food in the estuary (Quasim *et al.* 1969).

Large quantities of surplus basic food left in the estuary forms a rich source of food for benthic fauna. Pillai (1978) has reported that, judged by any standards, the benthic production in the Cochin backwaters is quite rich. His study has showed that the production of macrobenthos, in terms of annual mean standing crop (wet wt.) is 352.05 Kg/ha. According to Townes (1938) a natural lake yielding 300 Kg/ha of bottom fauna is normally rich. Thieneman (1925) has classified a lake bed producing 1000 animals or less per $m^2$ as oligotrophic, one producing above 2000/$m^2$ as eutrophic and one between 1000 and 2000 as mesotrophic. In Cochin backwater the average number of macrofauna recorded is 2332/$m^2$. This indicates that the lake is eutrophic.

The highly productive waters of the estuary supports a good resource of fin fishes and shell fishes. A number of commercially important penaeid prawns like *Penaeus indicus*, *Metapenaeus dobsoni* and *M. monoceros* are fished in appreciable quantities from the estuary. Similarly the estuary is noted for the species variety and abundance of fin fishes. The well esteemed food fishes such as chanos, mullet and etroplus abound in the estuary. Huge quantities of bivalve molluscs are collected from the backwaters which form the raw material for a number of industries.

Accelerated human activities for exploitation of the estuarine resources, utilisation of estuary for various developmental purposes and stress of population from the highly dense hinterlands, all have a negative impact on the ecology of the estuary.

POLLUTION AND OTHER ECOLOGICAL PROBLEMS

It seems that there is an inherent notion in the human beings that the water bodies are meant for waste disposal. This attitude shown to the aquatic systems has resulted in the rapid deterioration of the aquatic environmental quality throughout the world. Cochin backwater system is no exception in this respect. Many scientific reports of the investigations conducted in Cochin backwaters unquestionably prove that this rich and dynamic ecosystem is undergoing detrimental ecological alterations, in varying paces at different points, which will undermine the resource potential of the estuarine system.

Toxic industrial effluents from a number of Industries, municipal and urban sewage, agriculture and land run off containing pesticides, fertilisers and their residues are the major pollutants which have a negative impact on the ecosystem. Rapid development of Cochin as a major port has augmented the pollution problems several folds due to the discharge of waste from cargo ships and oil spills from tankers. Widespread use of the backwater system for transport, coconut husk retting and other human activities also contribute to the ill-health of the estuarine complex. Construction of the Thanneermukkom bund across the backwater system can be deemed as a major 'ecological offence' done to this system.

## INDUSTRIAL POLLUTION

There are a number of industries situated on the banks of all the rivers which empty their contents into the estuary. Thus, fairly wide areas of the rivers have lost ability to keep the natural equilibrium (Nair & Pillai 1982). The Periyar river brings in a major share of the industrial effluent as the Eloor industrial complex is on the banks of Periyar. Table I lists the industries, their products and effluents.

The estuary receives $186.6 \times 10^6$ L. of industrial effluents per day. The effluent contains a number of toxic ingradients like acids, alkali, heavy metals, suspended solids and a number of other chemicals which have immediate and long term effects on the organisms.

A number of instances of fish mortality reported from the backwaters indicate the magnitude of industrial pollution in this area. All these reports (Unnithan *et al.* 1977; Venugopal *et al.* 1980; Nair *et al.* 1980; Shynamma and Vijayakumar 1980) show that high ammonia and pH was the causative factor for the fish mortality. Unnithan *et al.* (1977) have reported ammonia values as high as 172.2 ppm and pH of 11.7. Morphological observation of dead fish showed widely opened mouth, distended opercula and ruptured abdomen. Heavy damage to the gill filment also was noticed. Ramani (1979), has reported high concentration of copper and zinc, high suspended material and COD in the region receiving industrial effluents. Unchecked discharge of industrial effluent has converted certain regions of the estuary into biological deserts.

According to Railey *et al.* (1972) phosphate content in excess of 200 µg/l is a prima facie evidence of pollution and a potential cause for eutrophication. Ketchum (1967) stipulates that 2.55 µg at/l is the maximum limit of $PO_4$ concentration which could be accepted as the danger signal in evaluating the eutrophication of an estuary. Concentrations above 0.01 mg. of inorganic phosphorus/l will support growth of aquatic organisms (Albaster, 1964). Joseph (1974) has reported very high concentration of plant nutrients especially inorganic phosphate (40 µg at/l) and nitrite (5 µg at/l) in Periyar near the industrial belt. Due to this high nutrient enrichment, the backwater system is under constant threat of eutrophication. Though not on a massive scale eutrophication is noticed in the back-water occassionally.

SEWAGE POLLUTION

About 10,000 people are added to the urban population of the fast growing city of Cochin. Total consumption of water is estimated aseighty three million litres./day. A good portion of this water finds its way into the drainage. The drainage system at present does not cover the entire city and sewage treatment facilities available are inadequate. Hence a good amount of raw sewage and sullage water mixed with domestic waste is carried along the six major canals and drained into the backwaters (Vijayan et al. 1976). Another source of sewage is from the ships and other vessels. Cole (1979) has clearly stated that as far as living resources of the sea are concerned, de-oxygenation in estuaries and coastal water, and the deposit of organic rich sediments and substantial load of metals and persistant organics, are the principal adverse characteristics of sewage. Highly destructive and irreversible physical, chemical and biological changes in the surrounding environments are noticed in areas of continuous sewage outfalls. Drastic changes in the abundance and diversity of benthic organisms and fishes and prevalence of diseases like fin erosion are the immediate aftermath of sewage dumping in coastal waters. Microbial contaminations of fishes is another serious problem which makes sea food unacceptable to consumers. Gore et al. (1979) have reported intense faecal contamination in the backwaters resulting in a high density of coliform bacteria in the water and sediments. The fishes and bivalves collected from the backwaters also contained a rich percentage of these coliforms.

Due to the high organic load of the sewage, oxygen consumption rate far exceeds the replenishment rate which results in anaerobic conditions. Vijayan et al. (1976) have reported very low oxygen values (o.o5 ml/l) and very high BOD values (420.6 ppm) in the areas of estuaries receiving sewage. Similarly high sulphide (4.92 ppm) was also noticed in the polluted areas. Another serious disadvantage of sewage is its high nutrient contents which can lead to eutrophication. In addition to the high nutrient load brought to the estuary by the sewage it is mentioned elsewhere that the factory effluents also form an important source of plant nutrients. Thus a 15 Km. stretch of the estuary from Thevara to Varapuzha can be considered as a highly succeptible area for eutrophication.

OIL POLLUTION

Though oil is handled since the last 30 years no major oil spill has occurred in the port waters. About 200 to 250 oil tankers are transporting more than 4 million tons of oil in an year through the Cochin Port. The sources of oil pollution are spillage from tankers, pumping out of oily ballast water by the tankers and pumping out of oily bilge water by the cargo vessels. Out of these the major contributor is spillage in the operation of oil carrying tankers. Numerous mechanised vessels plying through the waters also are a source of oil pollution. Oil films floating in the waters are frequently encountered especially in the port waters.

Crude oil is a complex mixture and whereas all fractions have some effects on living organisms; some fractions of the aromatic hydrocarbons like benzene, toluene etc. are acute poisons to the organisms. It is found that hydrocarbons incorporated into a particular marine organism are stable regardless of their structure and are passed through many members of the marine food chain without alteration (Blumer, 1969). This is made possible because the hydrocarbons entering the body of the marine organisms become part of the lipid pool.

The harmful effects of oil on the aquatic organisms are numerous and varied. For marine organisms, disruption of chemoreception by oil is viewed as both likely and of important ecological consequence (Blumer, 1969; Olla _et al_. 1980.) Chemosensory disruption by various petroleum hydrocarbons and oil fractions have been reported in lobsters (Atema and Stein, 1974) and in shore crabs (Taka hashi and Kittredge, 1973). Anaesthesia, narcosis, cell damage etc. are some other effects of oil on marine organisms.

## DREDGING

Due to silting, the port area is periodically dredged to maintain **necessary** depth for navigational purposes. Approximately one to one and a half metres of semi solid silt deposited is annually dredged and this mud is used for reclamation of large portions of the water front which are potential areas for fish farming. Heavy siltation occurring in the backwaters resulting from the dumping of dredged material has led to the formation of several small islands close the harbour areas. The reclamation work going on leads to the depletion of available water body and a consequent loss in fauna and flora (Quasim and Madhupratap 1979). According to Balakrishnan and Lalithambika Devi (1983), the dredging operations caused damage to the benthic, nektonic and planktonic communities by dislocation, clogging, blinding etc. The operation is repeated every year at the time when most of the animal and plant communities are about to spawn. This not only affects the population as is evident from the decline of rock oyster (Crassostrea spp.) in the dredging area but affects the food web also. The larvae of Oyster form one of the important food items of several organisms including fish larvae. Dredging operation also brings up pollutants, particularly the less dredgable ones which are settled along with the sediment, to the biologically active zone.

COCONUT HUSK RETTING

Another source of pollution in the backwater is due to retting of coconut husk. Considerable areas of the estuary are at present used for husk retting. Thus at Vaduthala (5 Km. upstream from harbour mouth) more than 40 wells covering an area of 2,000 sq. meters are used for this purpose.

As a result of retting large quantities of organic substances like pectin, pentosan, fat and tanin are liberated into the medium by the activity of bacteria and fungi. Decomposition of pectin results in the production of sulphide. Strong smell of hydrogen sulphide is characteristic of retting zones.

Remani (1979) has reported increase in organic content with low and fluctuating oxygen values (0.05 ml/l), high BOD (513.7 mg/l) and sulphide (4.97 mg/l) resulting in the decline of the abundance of fauna, a high population density of tolerent indicator organisms and decline in the fish catch in the retting area. Decaying of coconut husk result in the formation of a black layer of organic material which besides affecting the production of benthic fauna also spoils the spawning ground of commercially important fishes.

## THANNEERMUKKOM BUND AND ASSOCIATED PROBLEMS

Construction of a 1.4 Km. long barrage across Vembanad lake at Thanneermukkom has resulted in widespread ecological changes in the backwater. It has upset the natural balance of the system. The decision to construct the bund was taken at a time when the terms ecology and environment were alien to planners and developers. It was constructed to protect the incursion of salt water to facilitate and augment rice production in the low lying Kuttanad paddy fields. With the closure of the bund, free flow of water was curtailed and stagnation resulted. This has resulted in multifarious environmental problem. Thus acidity of soil and water increased resulting in low primary production and less yield from paddy fields. The paddy cultivation practiced here is with the intensive use of fertilisers and pesticides. It is estimated that more than 46 different formulations of pesticides amounting to 1000 tons are used in these areas on every crop season (State of the Environment in Kerala - First report - 1982). Similarly, on an average 27,200 tons of phosphate fertilisers in the form of mussori phosphate, factomphos etc., 13,300 tons of potash in the form of murate and 41,200 tons of urea are also used in each crop season. This gives an indication of the quantities of pesticides and fertilisers reaching the backwater system. Before the construction of the bund all these leached out pesticides and fertilisers were amply diluted and discharged into the sea due to the free flow of water. Now these are accumulated in the sediment and water of this region along with numerous other wastes generated by the people of this thickly populated area.

Before the construction of the bund, Kuttanad waters supported a rich fishery resource. This region was renowned for the high priced and well relished fresh water shrimp Marcrobrachium roseenbergii. With the construction of the bund the catch of it declined from a substantial 5 ton a day to a meagre 500 Kg. (Balakrishnan and Lalithambika, 1983) Similarly there is a rapid reduction in the quantity of other crustaceans, fin fishes and molluscs. The reason for the considerable reduction in the stock of Macrobranchium is positively due to the prevention of its breeding migration.

So far, no investigation is carried out to assess the damage caused by the pesticides and their residues in the area. Studies carried out in other parts of the world has shown that pesticides even at very minute quantities inhibit photosynthesis. 100% mortality is noticed in shrimps and crabs exposed to DDT at concentrations of less than 0.2 ppb (Butler, 1965) and at 0.1 ppb levels at interferes with the growth of oysters (Butler, 1966).

TABLE - I

INDUSTRIES, THEIR PRODUCTS AND EFFLUENTS

| Name | Products | Effluent qty. (10° l./day) | Major toxicants |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| Rayon manufacturing | Rayon yarn, sodium sulphate, sulphuric acid | 18.0 | Low pH, suspended solids sulphides, sinc, lead, BOD, COD, $SO_2$ and $H_2S$ |
| Fertilizer | Sulphuric acid, Phosphoric acid, NPK fertilizer, Gypsum Ammonium chloride | 55.0 | Low pH, suspended solids phosphates, fluorides, ammonial nitrogen, free ammonia, $SO_2$ |
| Rate Earth Salts | Rate earth chloride, Trisodium phosphate, Rare earth oxide, Thorium concentrate, Rare earth fluoride | 3.0 | High pH, suspended solids phosphate, fluoride, Lead, radioactive material |
| Insecticides | Technical DDT, Technical BHC, 50% formulated DDT, BHC, Orthotuluidine, Benzene, Para dichlorobenzene | 1.2 | DDT, BHC, chlorinated hydrocarbons, residual chlorine, low pH, chlorine |
| Metallurgical Industry | Slab zinc, cadmium, sulphuric acid ammonium ingots | 36.6 | Low pH, suspended solids, sulphides, arsenic, cadmium, copper, zinc, lead, |

| 1 | 2 | 3 | 4 |
| --- | --- | --- | --- |
| | | | SO2, fluoride |
| Distillary | Rectified spirit | 0.4 | Colour, suspended solids, BOD, COD |
| Rubber Industry | Automobile tyre, tube, flaps | 1.7 | Phosphate, Amm. nitrogen |
| Inorganic chemical | Copper sulphate, copper oxychloride, sodium aluminate, alum, pottassium chlorate | 0.6 | Suspended lead, zinc, copper, chromium, residual chlorine/ chlorine gas |
| Chloralkali | Caustic soda, chlorine gas, sodium hydrosulphate, bleaching powder, hydrochloric acid | 10.1 | Suspended solids, high pH, mercury, residual chlorine, zinc, barium, chlorine |
| Oil | Petroleum Products | 27.0 | Cyanides, fluorides, suspended solids, phenolic compounds, oil and grease, lead |
| Paper | News print | 33.0 | Suspended solids, colour, BOD, COD, mercury |

# CHAPTER-III

## HYDROGRAPHY OF COCHIN BACKWATERS

### INTRODUCTION

The hydrographical conditions of the backwater system is influenced by seasonal changes. The system is dominated by sea water during summer while the entire stretch of the system is fresh water in nature during the peak monsoon period. Seasonal changes in the hydrography is reflected in the inhabitants also. Thus an understanding of the environmental parameters is quite essential to assess the ecology and inter-relationship ofthe organisms. The marked changes in the environmental charavteristics enable us to demarcate three distinct seasons viz., pre-monsoon period (February-April) of high saline water, a monsoon period (May - September) of very low or negligible salinity and a post-monsoon period (October-January) noted for the highly fluctuating salinity. Like salinity, other environmental parameters also show noticeable changes with these seasons. The division of the season is only arbitrary and it fluctuates depending on the onset of the monsoons.

### MATERIALS AND METHODS

The water samples were collected monthly from five stations for a period of two years from May 1980 onwards (Fig. 2 ) The surface samples were collected using a bucket and bottom samples with a Retner sampler.

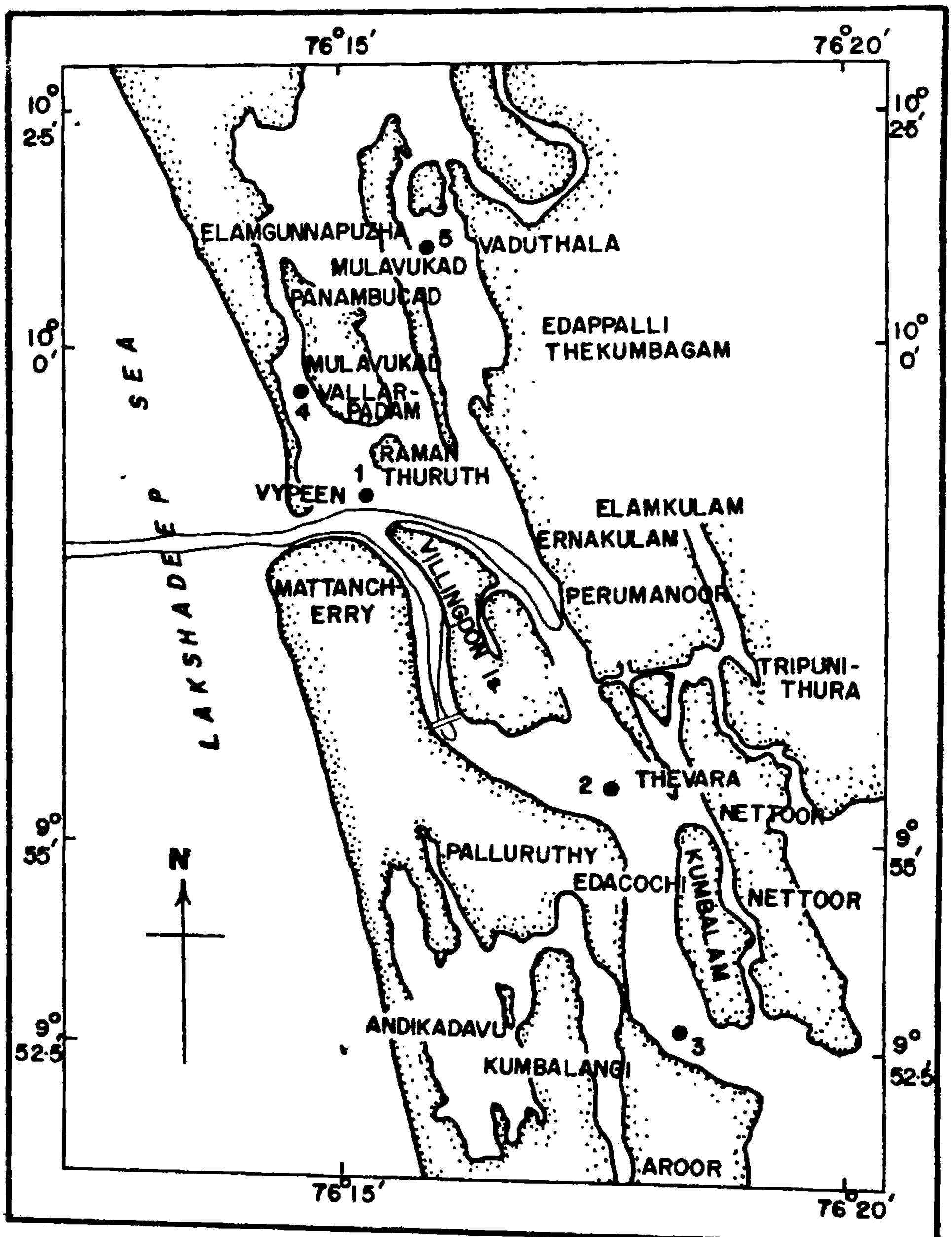



Fig. 2 LOCATION OF STATIONS

The temperature was noted with a calibrated 1/10 °C thermometer. The samples for dissolved oxygen were immediately fixed and that for salinity were collected in salinity bottles. The pH was recorded with a calibrated pH meter. Samples for various other parameters like ammonical nitrogen, nitrite nitrogen, nitrate nitrogen and inorganic phosphate were transferred to clean polythene bottles and were analysed on the same day. Estimation of the parameters were done as per the methods described by Strickland and Parsons (1972).

## RESULTS

### SALINITY

Of the various hydrographic parameters studied, salinity is the most important factor which showed maximum variations in space and time. It has a profound effect on the various physical processes in a tropical estuary. This information on the profile and pattern of the salinity distribution will enable us to understand the circulation and mixing, tidal influence, amount of fresh water inflow etc. which greatly influence various other parameters of the estuary. It has also got significant control over the inhabitant also. Kinne (1966) has emphasised the view that salinity is the 'ecological master factor' controlling the life of estuarine animals.

PRE-MONSOON

Pre-monsoon period is characterised by a vertically homogenous salinity in the estuary (Fig. 3-5 ) Even at the end of post-monsoon (January) a homogenous pattern in salinity distribution was noticed at Station . During pre-monsoon, the salinity steadily increased and attained the maximum value (34.8 ‰) in April. Thus, during pre-monsoon, the backwater becomes simply an extension of the adjoining sea (Sankanarayanan and Quasim, 1969) The influence of the sea water was very much pronounced as the saline water is traceable upto the head of the estuary (Haridas, et al. 1973).

In other stations also the salinity distribution was more or less same, the major difference being spatial. The recovery of salinity in Stations away from the harbour mouth was gradual and a pronounced vertical gradient in salinity also was noticed indicating some amount of stratification during early pre-monsoon. As the pre-monsoon advanced, this stratification weakened and a well mixed condition prevailed during March-April in all Stations.

MONSOON

With the onset of monsoon, abrupt changes were noticed in the salinity distribution (Fig. 3-5 ) Large quantities of fresh water brought into the estuary through the rivers and land run off considerably lowered the salinity both at the surface and bottom of the estuary. At the monsoon reached its zenith in July, the entire estuary is converted into a fresh water body. But in stations near the harbour mouth, high saline water was observed thus establishing a distinct two layered flow. Banse (1959; Ramamritham and Jayaraman, 1960, 1963) has reported that, during monsoon, the continental shelf is pervaded by cold, dense, waters upwelled from the sub-surface levels of Arabian sea. Thus the high saline water noticed in the stations near the harbour mouth is probably due to the intrusion of the upwelled Arabian sea water. With the retreat of the monsoon, salinity was found increasing in all the stations.

POST-MONSOON

With the cesation of the monsonal influx of fresh water in October, recovery of salinity started in all the Stations (Fig. 3-5). Stratification of the water column was distinctly evident. But as the post-monsoon season advanced, intensity of stratification was reduced thus establishing almost homogenous conditions in January.

TEMPERATURE

When compared to salinity, variations in temperature were not so pronounced. But seasonal variations were evident.

PRE-MONSOON

Highest temperatures were recorded in the estuary during the dry pre-monsoon months. From February onwards, both the surface and bottom water temperature rose and reached a maximum surface value of 33.1°C in April (Fig.6-8 ). No thermal stratification was noticed during this season and water remained well mixed. The maximum difference between surface temperature and bottom were 0.4°C.

MONSOON

The cold monsoon rains resulted in a sudden reduction of water temperature (Fig.6-8 ) The lowest surface temperature of 27.3°C was recorded at the zenith of the monsoon in July. There was distinct difference between surface and bottom temperatures. Thus the vertical thermal gradient was steep during this months.

POST-MONSOON

During post-monsoon, the temperature increased and the thermal stratification weakened (Fig. 6-8 ).

By December the thermal stratification was negligible and homogenity in temperature distribution was almost established.

## DISSOLVED OXYGEN

Dissolved oxygen in the estuary is influenced by various environmental parameters like salinity and temperature. Primary production and fresh water inflow also influence the dissolved oxygen values. Like salinity and temperature, dissolved oxygen also showed seasonal variation.

### PRE-MONSOON

This is the season of high salinity and temperature in the estuary and so low oxygen values were recorded during the pre-monsoon season (Fig9-11). As the water remained well mixed without a thermal stratification, there was not much difference between the surface and bottom oxygen values. The maximum surface oxygen value recorded during this season was 4.8 ml/l and that of bottom was 4.2 ml/l while the minimum value recorded was 2.8 ml./l at surface and bottom.

### MONSOON

A general increase in the surface oxygen values was seen during the monsoon months (Fig9-11). This is obviously due to the oxygen rich fresh water influx. Another factor is that the land run off and river water brings into the estuary a food load of nutrients which enhances the primary production resulting in oxygen enrichment of the water column. The maximum surface oxygen value observed was 6.8 ml./l. Though the surface oxygen increased, the bottom values showed a decline indicating that the consumption rate is greater than replenishment. The lesser oxygen replenishment in the bottom layers are due to the stratified conditions existing in the water column which prevents mixing. The higher consumption rate may be because more oxygen is needed for the biodegradation of the organic load brought in by the accelerated fresh water inflow. According to Quasim et. al. (1968), the low oxygen value in the bottom water is because of the high turbidity during this period which limit the primary production in the bottom layers.

POST-MONSOON

The bottom oxygen values showed a sharp increase (Fig.9-11). The difference between surface and bottom layers decreased considerably. This is because of the mixing of the water. The surface oxygen values were less than the surface values during the monsoon season.

HYDROGEN ION CONCENTRATION

pH also showed seasonal variations (Fig12-14) pH of bottom layers were more than that of surface. During the pre-monsoon season the pH of both surface and bottom were high. The highest pH value of 8.3 was noticed in Station No.2 during the month of April. With the onset of monsoon, pH also decreased. The lowest pH value recorded during the present investigations was 6.95 in the surface water of Station No.3. During post-monsoon, the pH of both surface and bottom layers increased.

Because of the buffering action of sea water the pH was more stable during the dry months when sea water dominated the estuary. But during monsoon season the pH was subjected to much fluctuations.

NUTRIENTS

The nutrients in the estuarine water varies considerably with the season. Thus with the onset of monsoon the nutrient load also increases. This show that the fresh water which dominates the estuary during monsoon period is nutrient rich. The various rivers which empty huge quantities of fresh water into the estuary are meandering through the fertile agriculture lands. These lands are all subjected to intense use of fertilisers. The heavy land run off during the monsoon months brings into the river substantial amounts of these phosphatic and nitrogenous fertilisers. This nutrient load is also supplemented by the nutrient rich urban sewage and factory effluents.

INORGANIC PHOSPHORUS

Seasonal cycle of inorganic phosphate both at the surface and bottom are shown in Fig.15-17. In all the stations and during all the seasons the bottom values were higher than the surface values. During pre-monsoon period the inorganic phosphate values decreased. The maximum pre-monsoon $PO_4$-P was in February and the values decreased rapidly in March. Though the values still came down in April, the difference between the March-April phosphate values were negligible when compared to the difference between February-March values. With the onset of monsoon $PO_4$-P values showed a considerable increased and reached the maximum values in July. Though the $PO_4$-P was high throughout the monsoon season, with the abatement of the intensity of monsoon, the values also decreased. The $PO_4$-P of the water column remained without fluctuation during October-November but increased in December and January.

NITRATE-NITROGEN

The seasonal variability of nitrate-nitrogen is illustrated in Fig.18-20. Except during the monsoon season, the nitrate values are less during all other months. During pre-monsoon and post-monsoon seasons, there was not much difference in the $NO_3$-N values. Though bottom values were higher than surface values, the difference also was not significant. But during monsoon season, very high $NO_3$-N values were obtained. Higher values were found in the Stations close to the harbour mouth. The difference between surface and bottom values were also much remarkable.

NITRITE-NITROGEN

Higher nitrite values were obtained during the monsoon period, when the estuary was dominated by freshwater (Fig.21-23) Like nitrate, during other months the variation was negligible. During the dry months no nitrite was obtained in some stations.

AMMONIACAL NITROGEN

Distribution of ammoniacal nitrogen in different stations are shown in Fig.24-26 If all other nutrients showed their peak during monsoon season, high values of ammoniacal nitrogen were obtained during the pre-monsoon season. A slight increase in the values were obtained during June and July. During the other seasons the ammoniacal values were low.

## DISCUSSION

Odum (1970) identified five important characteristics of the estuarine environment (a) the nutrient trap effect (b) the unique structure of estuarine water (c) the harsh nature of physical conditions and the resultant vulnerability of the estuarine organisms (d) sedimentary control of estuarine waters and (e) the key role of fresh-water inflow. A critical examination of the various hydrographic parameters investigated during the present study reveals that the monsoon plays a key role in controlling the various physico-chemical characteristics of the estuary. All the environmental parameters depends on the quantity of fresh-water influx and the interaction of the sea and the fresh water.

Out of all environmental parameters, salinity is the most fluctuating one. As salinity is the 'ecological master factor, it influences a number of biotic and abiotic factors. During the most of the period salinity on the backwaters cannot be predicted. In the case of salinity the stable season is only from February to April. During this season the salinity increases steadily attaining homogenous conditions with considerable vertical mixing. During monsoon, the estuary is fresh water dominated. But there is an intrusion of high saline water from the Lakshadweep sea. From this fresh water dominated season the estuary become a stratified one during post-monsoon period with high saline water in the bottom layers. Based on the cycle of events in the estuary, Sankaranarayanan and Quasim (1969) divided the year into three distinct seasons namely the stable season, the monsoon season and the recovery season. The results of the present investigation also agrees with this division. But it is not possible to earmark the months and say when these seasons start as it is dependent on the monsonal behaviour.

Thermal stratification was most intense during monsoon period. This stratification decreased during post-monsoon attaining homogenous conditions during pre-monsoon. Balakrishnan and Shynamma (1976) have reported diel variation in temperature values at all depths, all the layers becoming warmer towards the evening.

Oxygen values never reached saturation levels during the period of observation. But the lower temperature and fresh water conditions during the monsoon season is conducive for the dissolution of atmospheric oxygen in the surface layers. But as the bottom layer was loaded with organic matter brought down by the river water, more oxygen was used for the decomposition. Balakrishnan and Shynamma (1976) have reported that large fluctuations in salinity during active monsoon period might cause more saline organisms to die resulting in more utilisation of dissolved oxygen in deeper layers. The upwelled water entering the backwater is also deficient in oxygen. The recovery of oxygen in the bottom layers during post-monsoon indicates that decomposition of organic matter is less and replenishment with oxygen has commenced. Due to the vertical mixing of water during the pre-monsoon the water as a whole is almost uniformly oxygenated.

The inorganic phosphate values increased in all stations during monsoon period. This shows that the land run-off is a source of $PO_4$-P in the estuary. As the euphotic zone is minimum during monsoon due to the high turbidity, the primary production is limited to the upper layers thus leaving a good portion of the inorganic phosphate unutilised. This is one reason for the high $PO_4$-P values in the bottom. In the estuaries, the release of phosphorus from the silt occurs at a low oxygen concentration (Rochford, 1951). Thus the low oxygen values found in the bottom increases the $PO_4$-P in the bottom layers. Joseanto (1971) has reported a deepening of the estuary in the freshet season and shoaling in the dry season indicating a movement ofthe bottom substrata with the season. This substrata disturbance may also be playing a role in enhancing the $PO_4$-P content in the bottom water because according to Moore (1930, the phosphorus content of estuarine mud is 50 times greater than that of the water above and therefore, any stirring up of the sediment would greatly influence the concentration of phosphorus in the bottom layers. The cold upwelled water penetrating into the estuary during monsoon is also nutrient rich. In addition to this large quantities of urban sewage and industrial effluents reaching the estuary also increases the $PO_4$-P values. Thus Manikoth and Salih (1974) reported that the water samples at the mouth of Periyar showed Phosphorus content ranging from 5 to 6 ug at/l. The lesser $PO_4$-P values found during the pre-monsoon season is because of the greater utilisation and lesser enrichment. Thus Haridas <u>et al</u>. (1973) reported high biomass in the estuary in April and Quasim and Wyatt (1972) noted highest algal population in pre-monsoon period.

Nitrate, nitrite and ammonia are the various sources of inorganic nitrogen in the aquatic environment. Very high values of nitrate in the estuarine water during monsoon indicates that the river discharge and land run off is a contributor of nitrate. Ewins and Spencer (1967) reported that fresh water discharge and land run-off can increase the concentration of nitrate-N. The distribution of $NO_3$-N in the estuary was homogenous throughout the year. During the season when the estuary was dominated by marine water nitrate values were less. This suggest that sea water is poor in $NO_3$-N when compared to fresh water. During the dry season the euphotic zone also increases resulting in more use of nitrate-nitrogen. Except for the monsonal increase, nitrite-nitrogen values are negligible almost all the period. The bottom values were higher than surface values. The nitrite-N may be formed during the decomposition of organic nitrogen (Sankanarayanan and Quasim, 1969). Since nitrite-N is a transitory stage in the nitrogen cycle, its progressive decrease from the bottom to the surface may suggest its possible conversion into nitrate-N. No homogenity was noticed in the distribution of ammonia. As mentioned elsewhere the estuary receives large quantities of trade effluents with a good load of ammonia. The higher values of ammonia noticed during summer months may be due to these trade effluents because during this period the dilution of the effluent is minimum as a result of less river discharge. Decomposition of decaying organic matter also contributes the ammonical nitrogen in the aquatic environment.

## EXPLANATION TO FIGURES

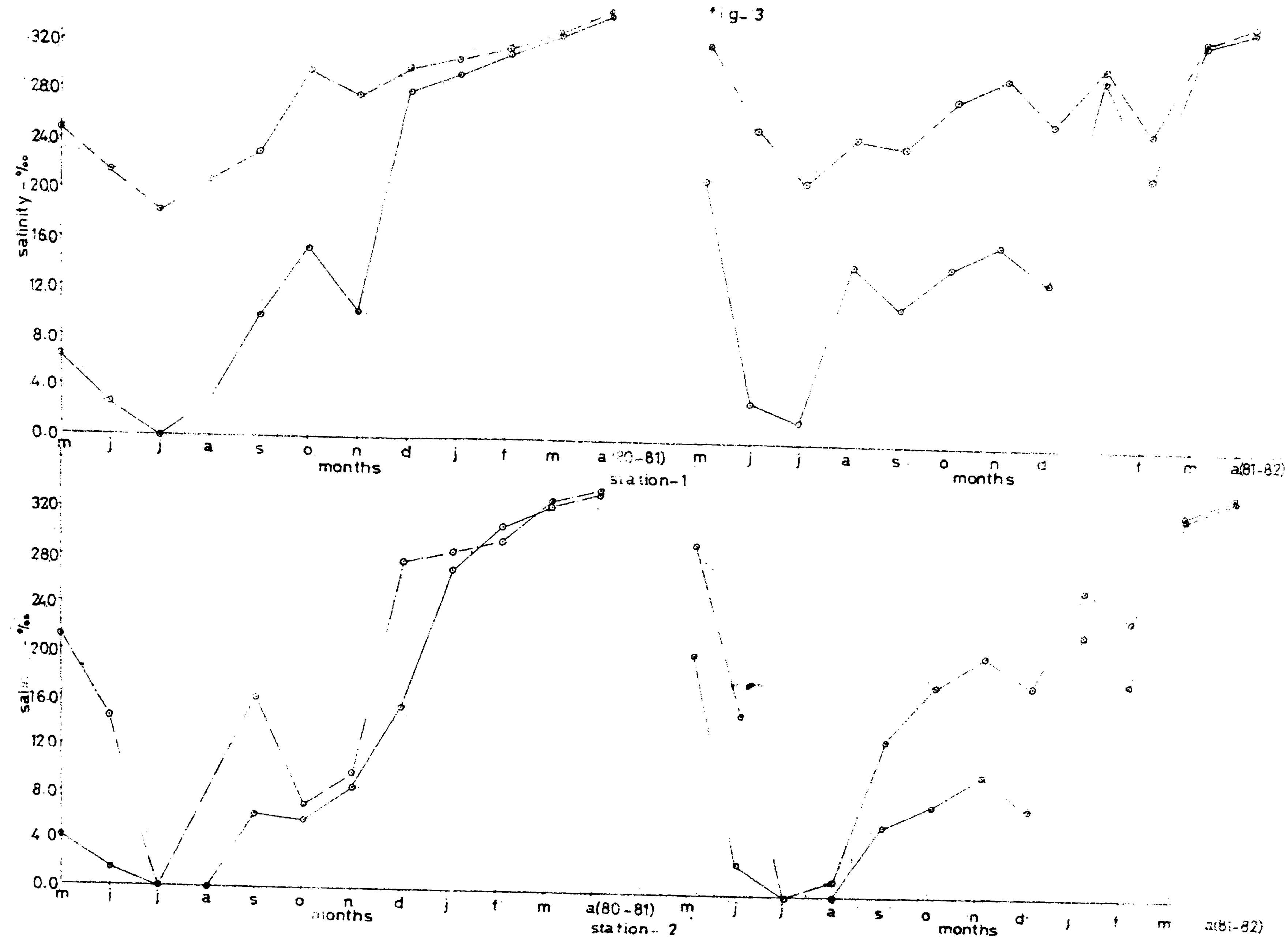
ENVIRONMENTAL CHARACTERISTICS OF COCHIN BACKWATER

| | |
|---|---|
| Fig. 3-5 | Distribution of salinity |
| Fig. 6-8 | Distribution of temperature. |
| Fig. 9-11 | Distribution of dissolved oxygen |
| Fig. 12-14 | Distribution of pH |
| Fig. 15-17 | Distribution of Inorganic phosphorus |
| Fig. 18-20 | Distribution of Nitrate nitrogen |
| Fig. 21-23 | Distribution of Nitrite nitrogen |
| Fig. 24-26 | Distribution of Ammoniacal nitrogen |

——— surface values

—.— bottom values

Fig- 3



salinity - ‰
0.0
4.0
8.0
12.0
16.0
20.0
24.0
28.0
32.0
m j j a s o n d j f m a (80-81) m j j a s o n d j f m a(81-82)
months
station-1
‰
m j j a s o n d j f m a(80-81) m j j a s o n d j f m a(81-82)
months
station- 2

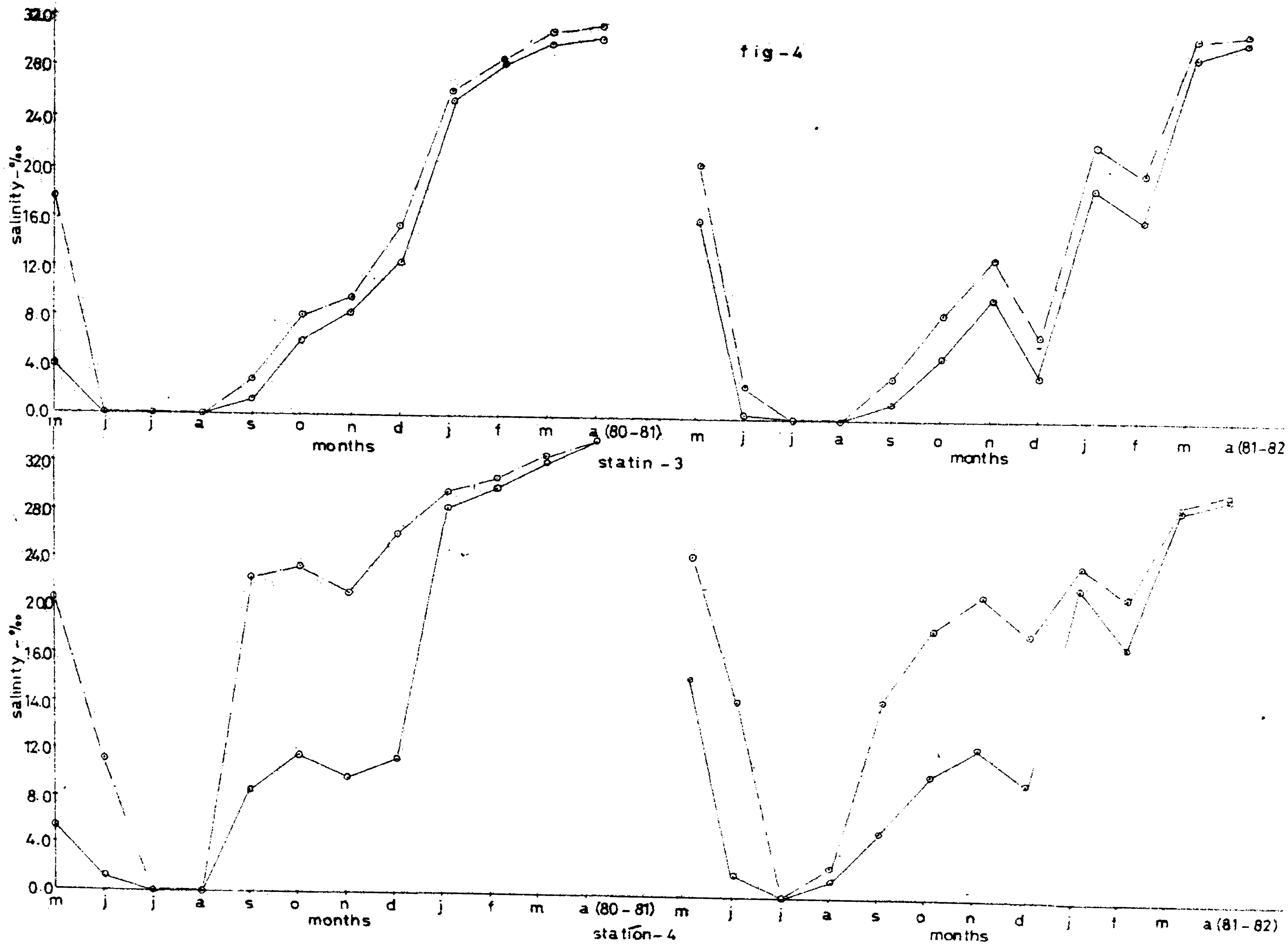
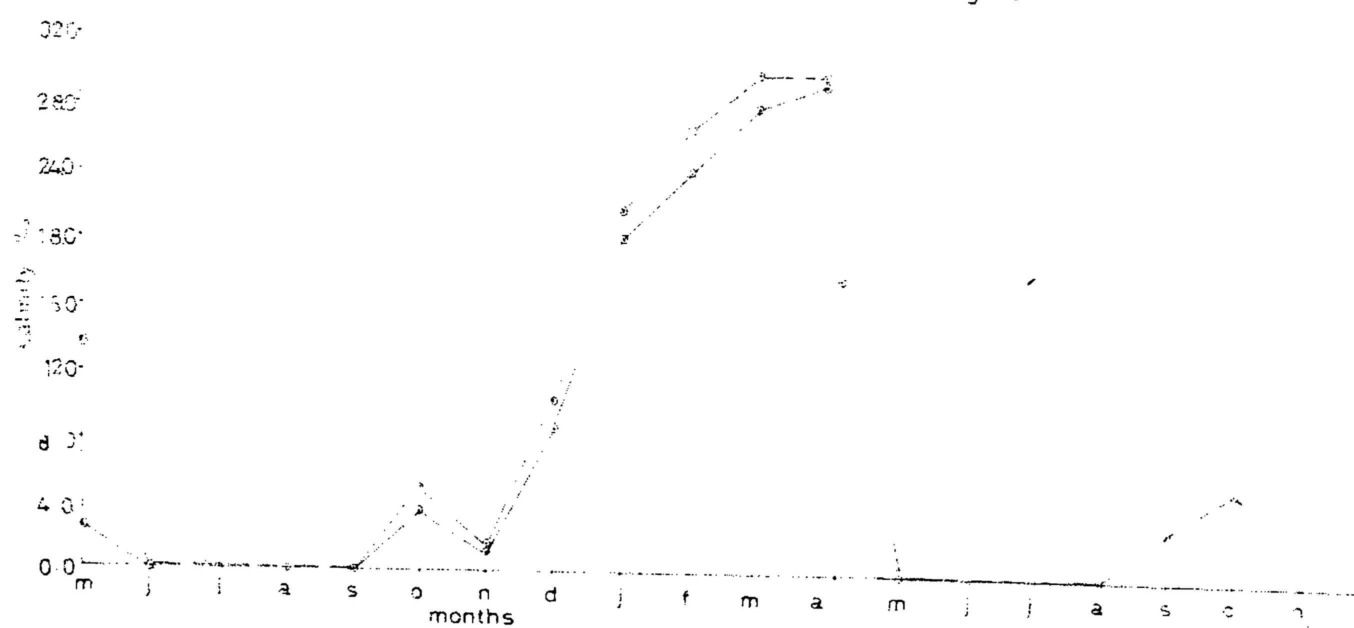


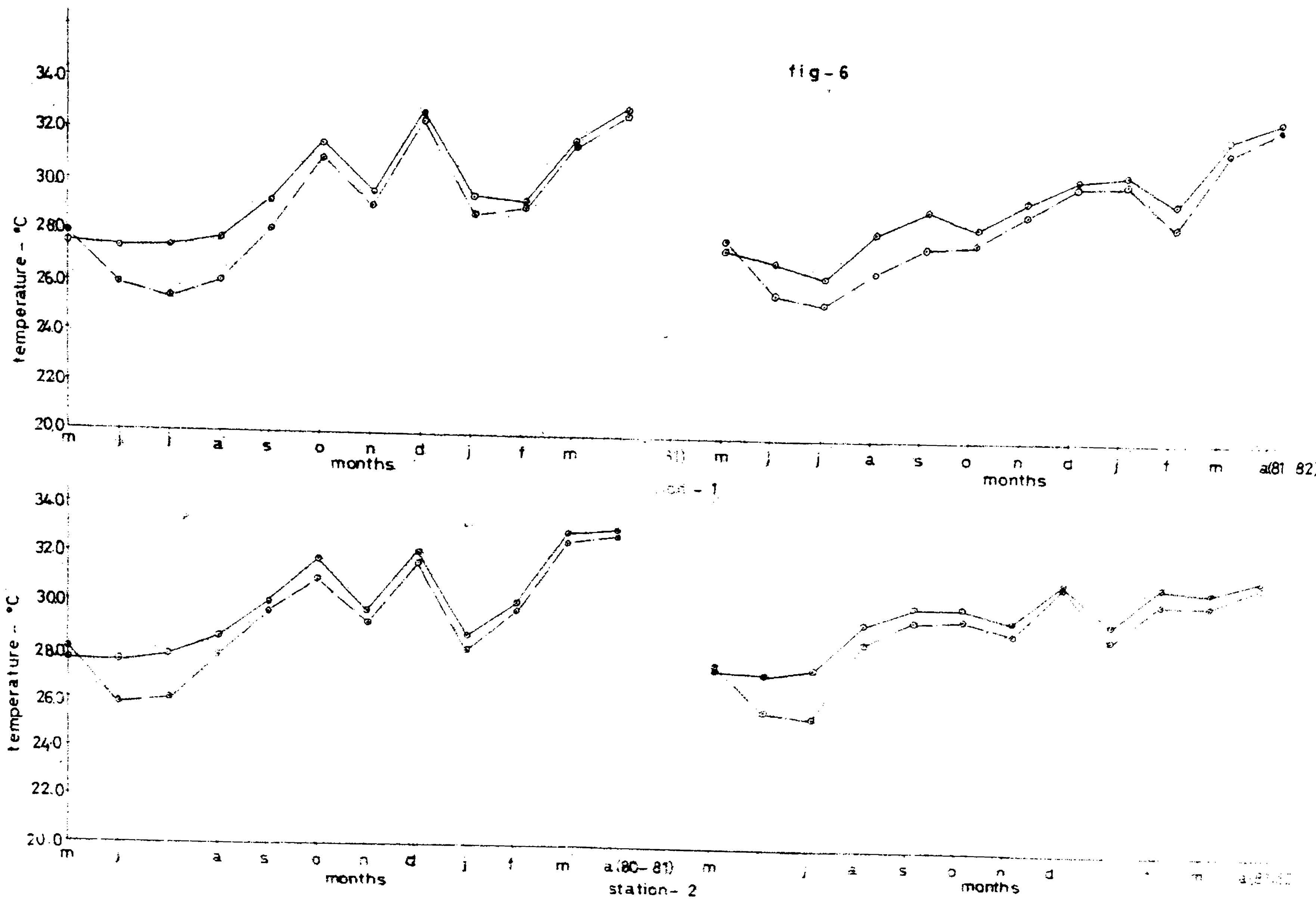
fig - 4
salinity - ‰
32.0
28.0
24.0
20.0
16.0
12.0
8.0
4.0
0.0
m j j a s o n d j f m a (80-81) m j j a s o n d j f m a (81-82)
months
statin - 3
salinity - ‰
32.0
28.0
24.0
20.0
16.0
14.0
12.0
8.0
4.0
0.0
m j j a s o n d j f m a (80-81) m j j a s o n d j f m a (81-82)
months
station- 4

fig - 5



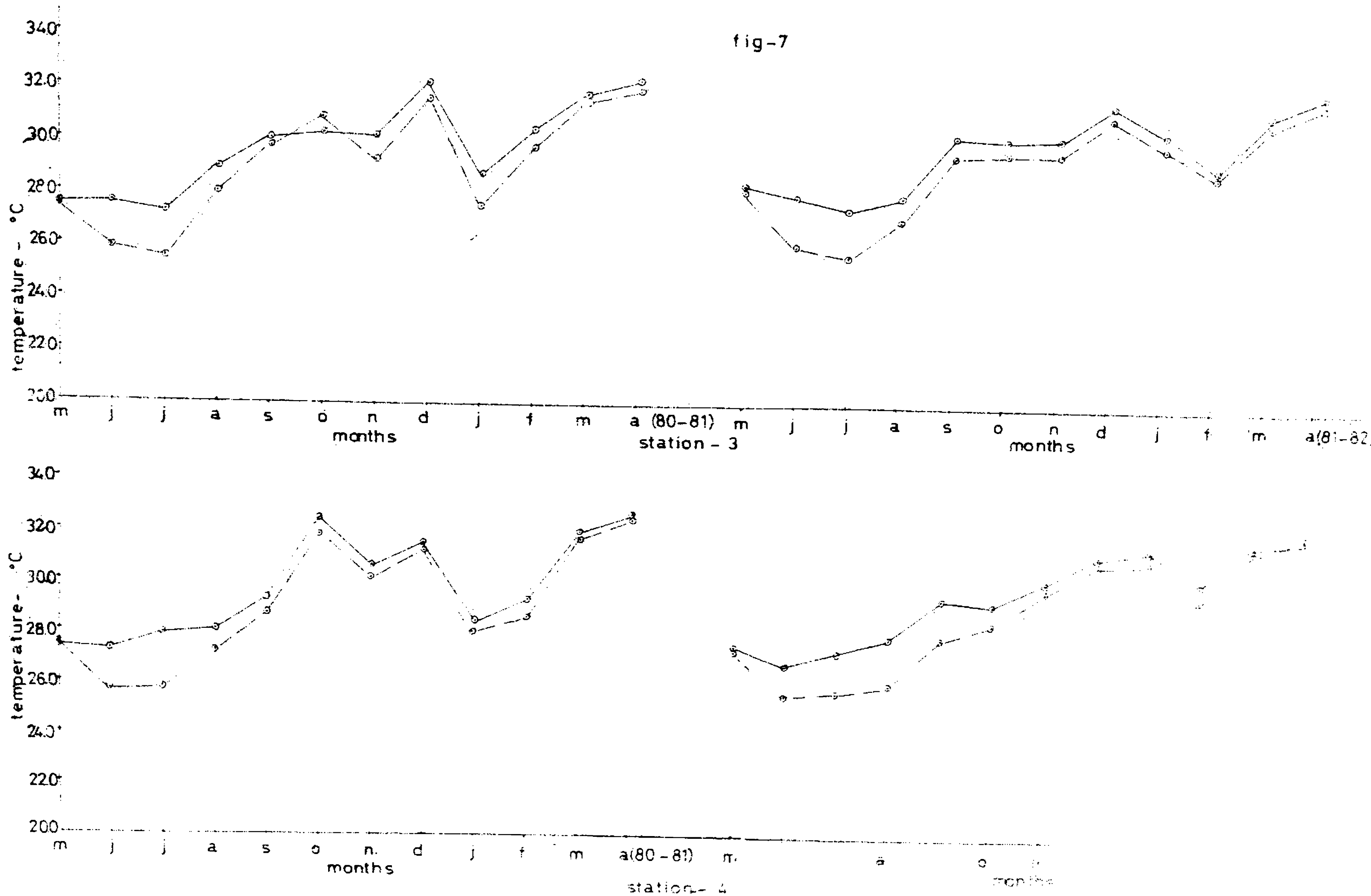

sation- 5

fig - 6



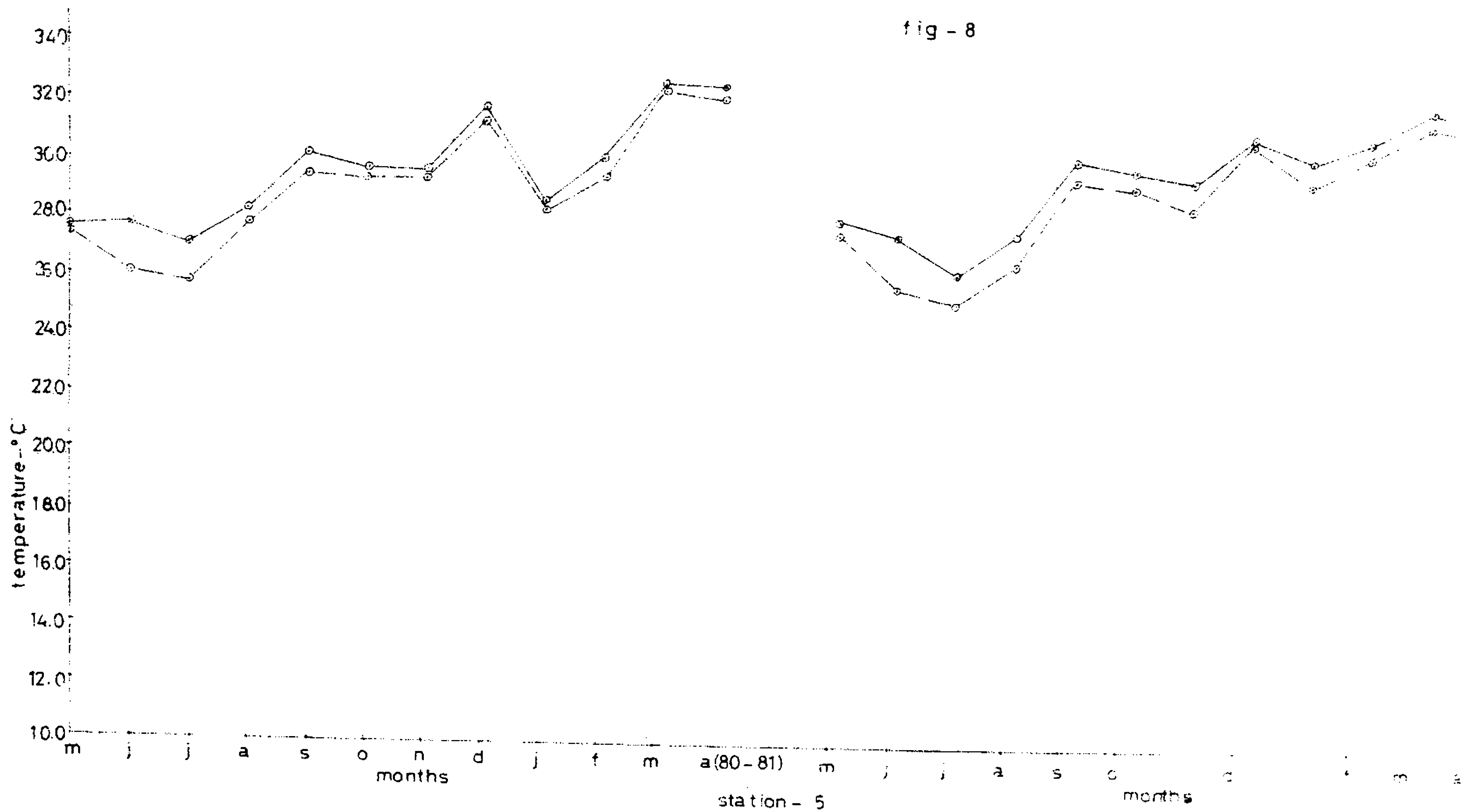
temperature - °C
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
m j j a s o n d j f m
months
m j j a s o n d j f m a(81 82)
months
m j a s o n d j f m a.(80- 81)
months
m j a s o n d m
months
station- 2

fig-7



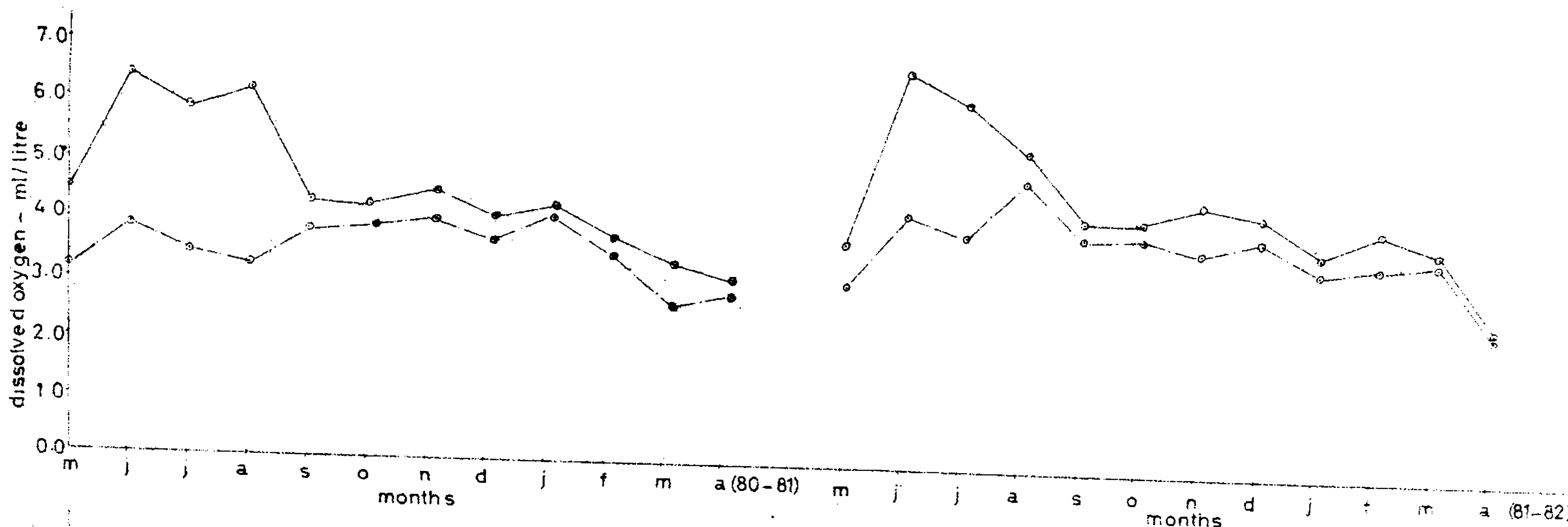
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
temperature - °C
m j j a s o n d j f m a (80-81) m j j a s o n d j f m a(81-82)
months
station - 3
months
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
temperature- °C
m j j a s o n. d j f m a(80 - 81)
months
station- 4

fig - 8

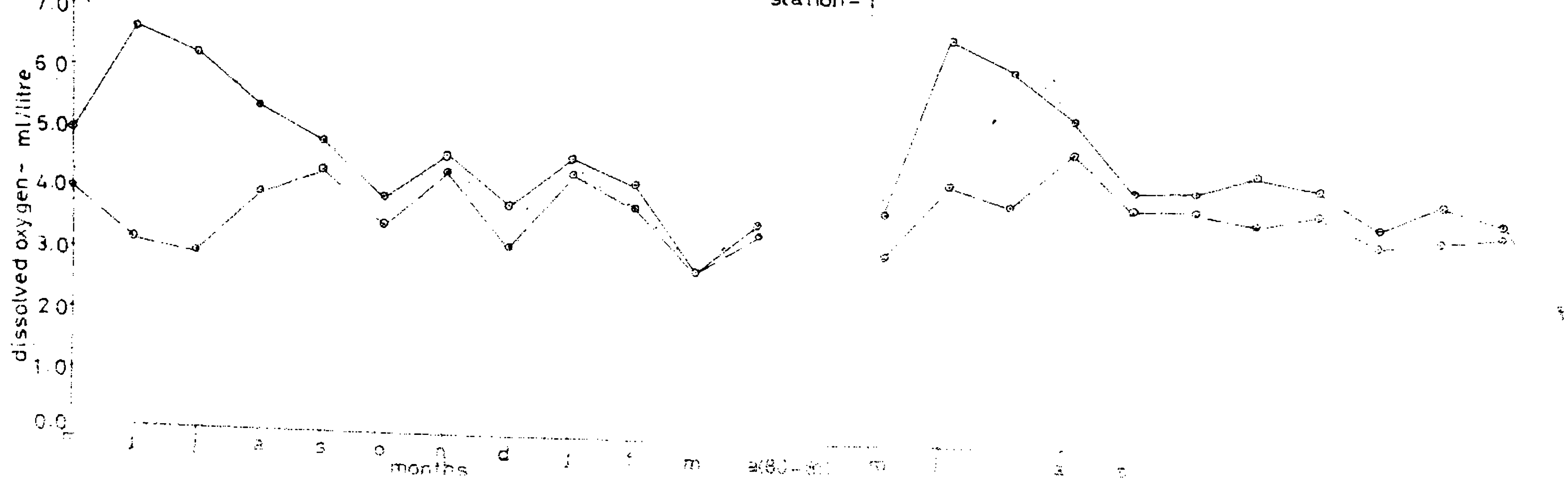


34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
temperature - °C
m
j
j
a
s
o
n
d
j
f
m
a (80 - 81)
m
j
j
a
s
o
months
station - 5

fig-9




station-1




station-2

fig-10

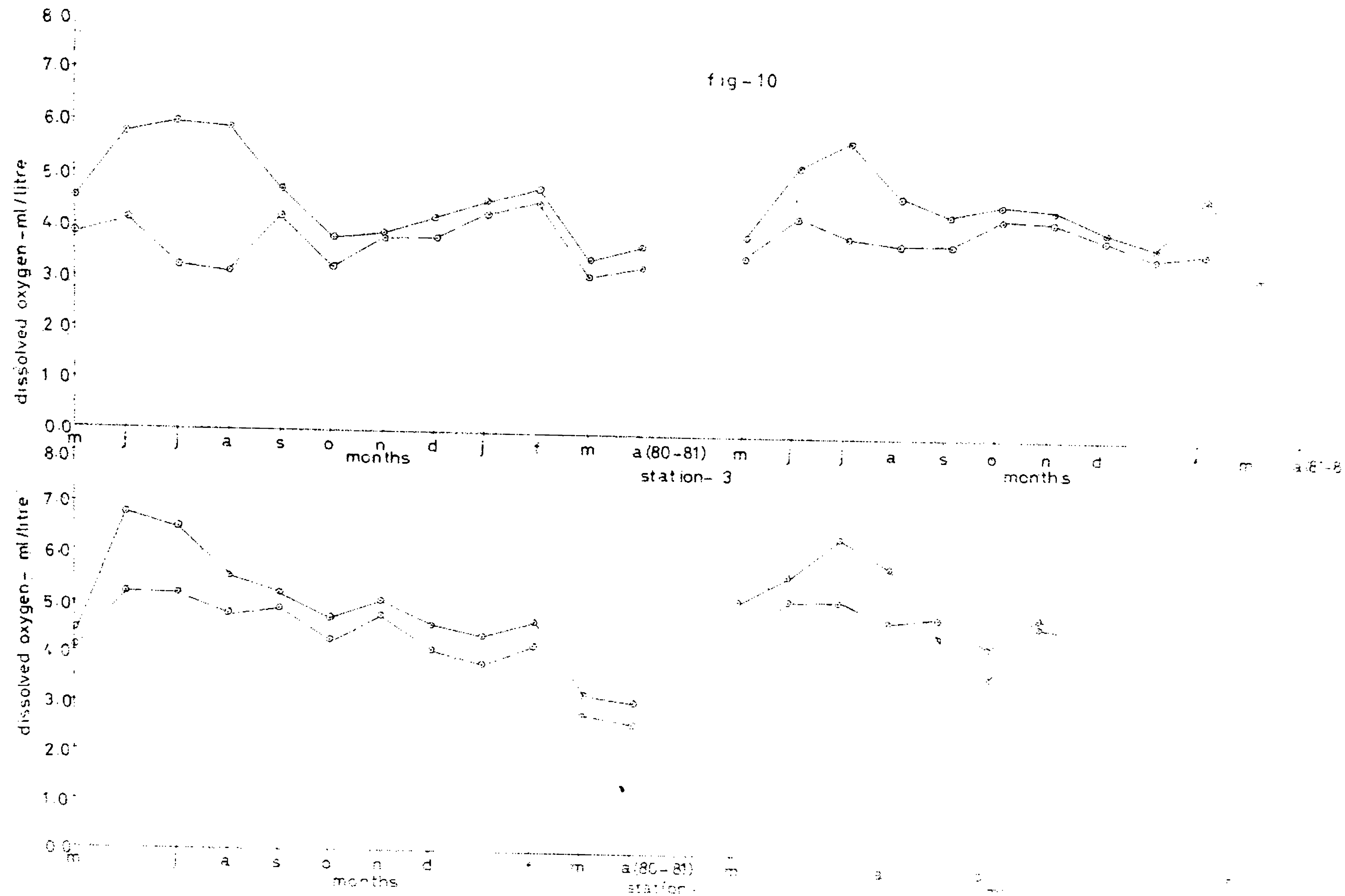
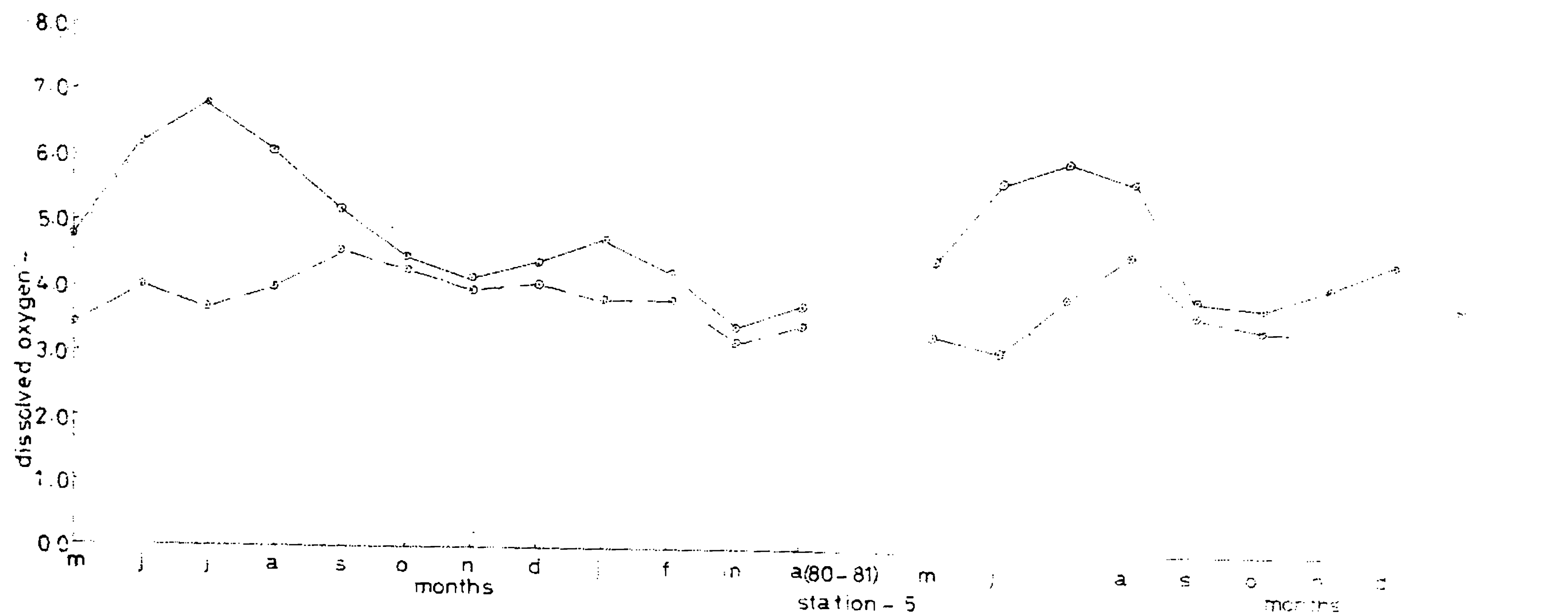

dissolved oxygen - ml/litre
months
a (80-81)
station- 3
months
dissolved oxygen - ml/litre
months
a (80-81)

fig-11



dissolved oxygen -
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a(80-81)
months
station - 5
m j a s o n d
months

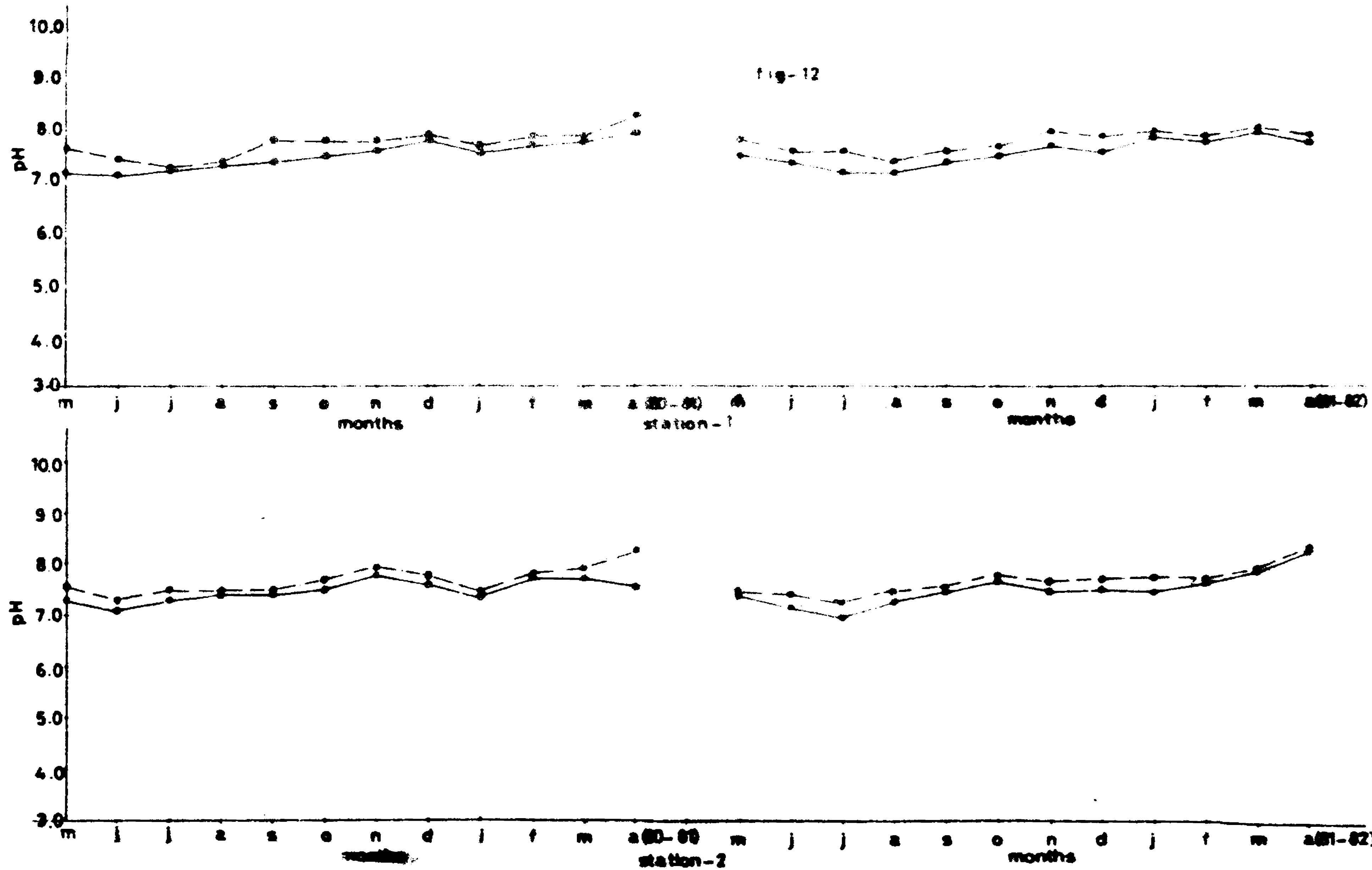
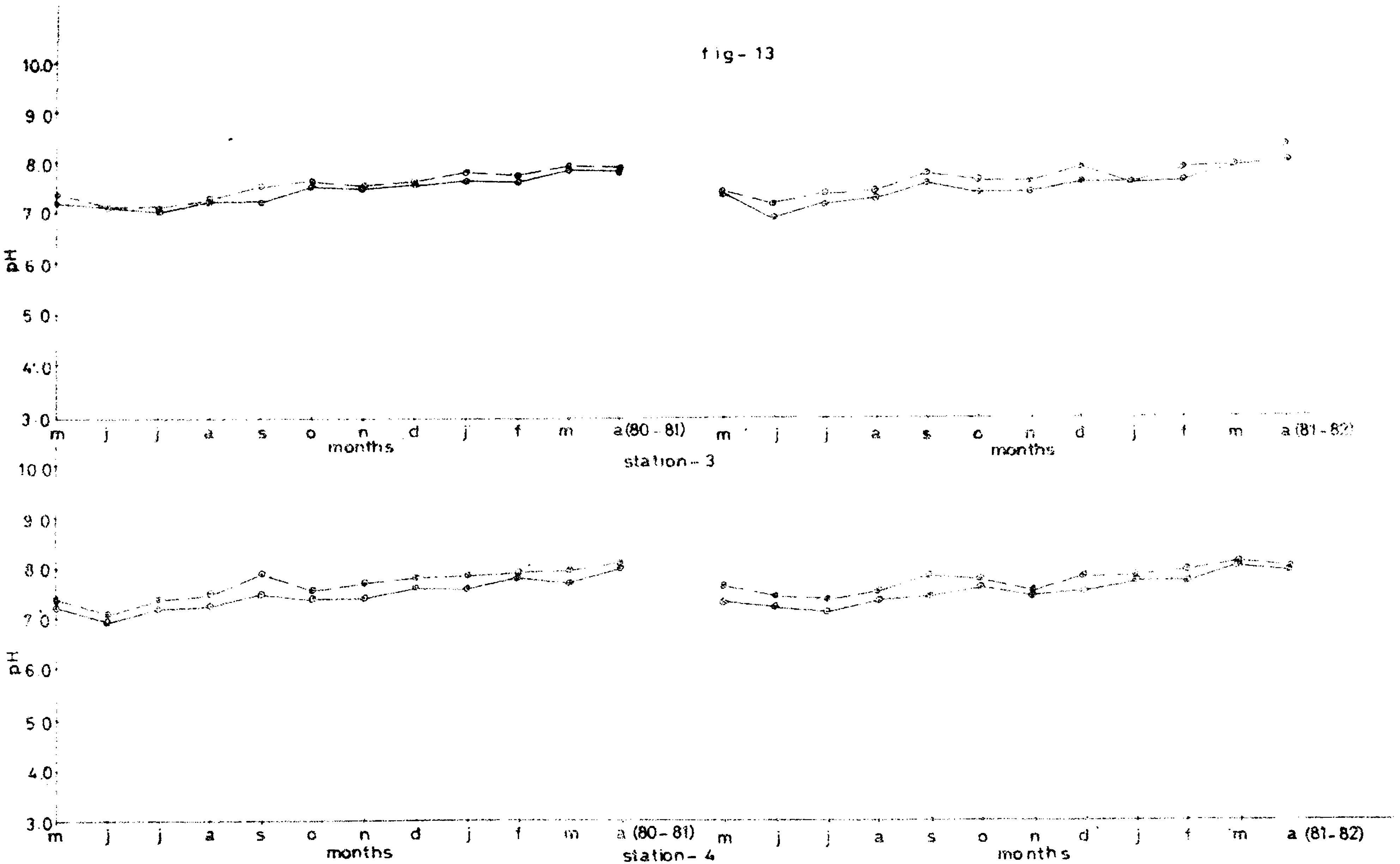

pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
m j j a s o n d j f m a
months
station-1
station-2
a(81-82)
months

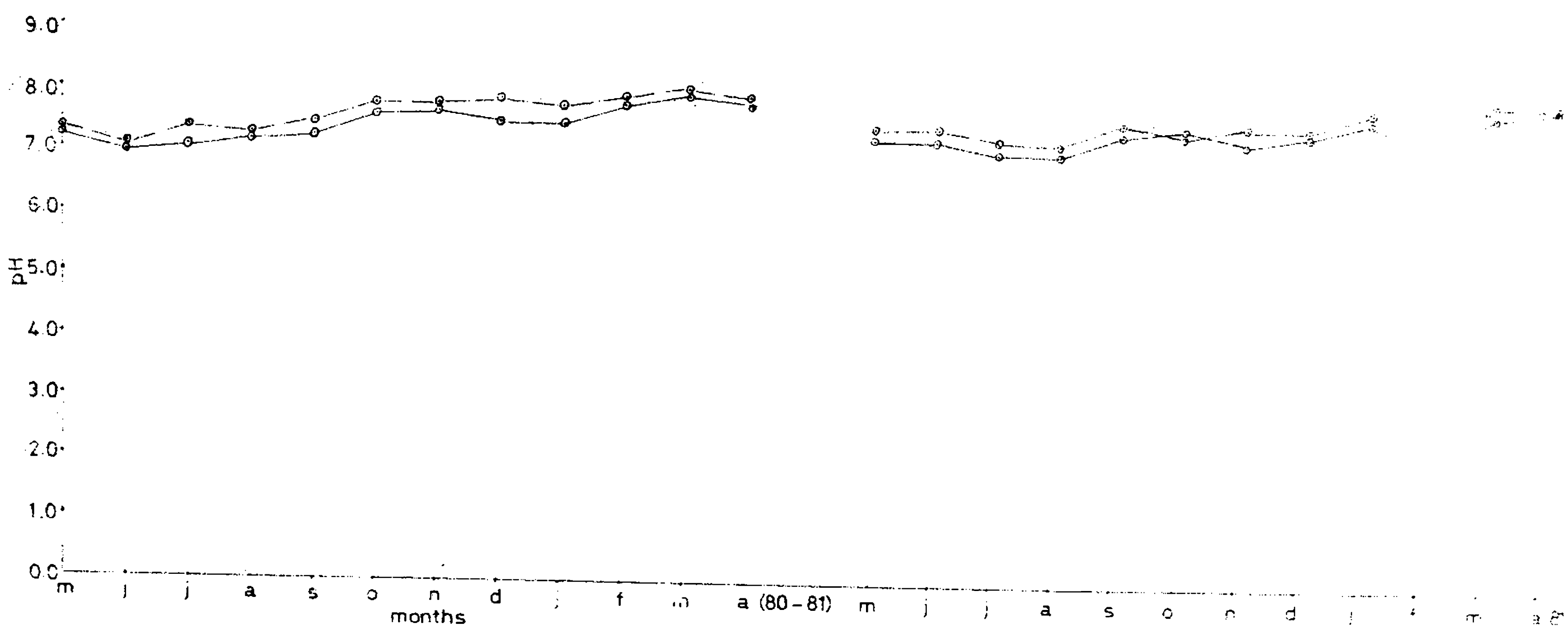
fig- 12

fig- 13



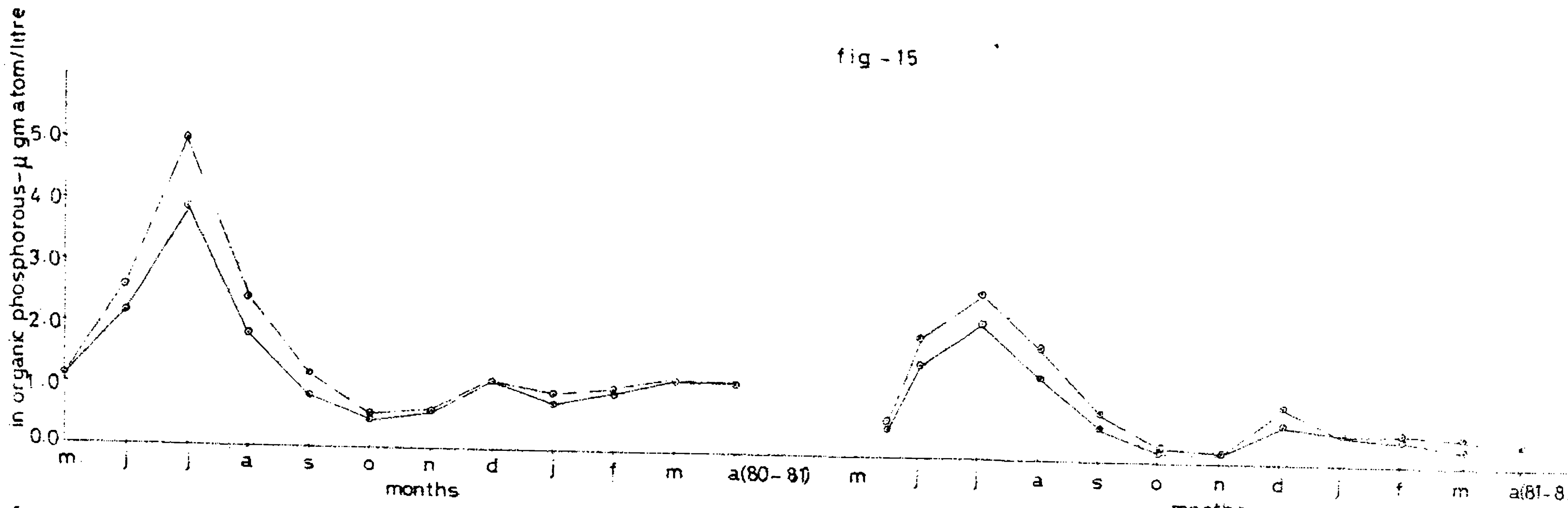
10.0
9.0
8.0
7.0
pH 6.0
5.0
4.0
3.0
m j j a s o n d j f m a (80-81) m j j a s o n d j f m a (81-82)
months
months
station - 3
m j j a s o n d j f m a (80-81) m j j a s o n d j f m a (81-82)
months
months
station - 4

fig-14

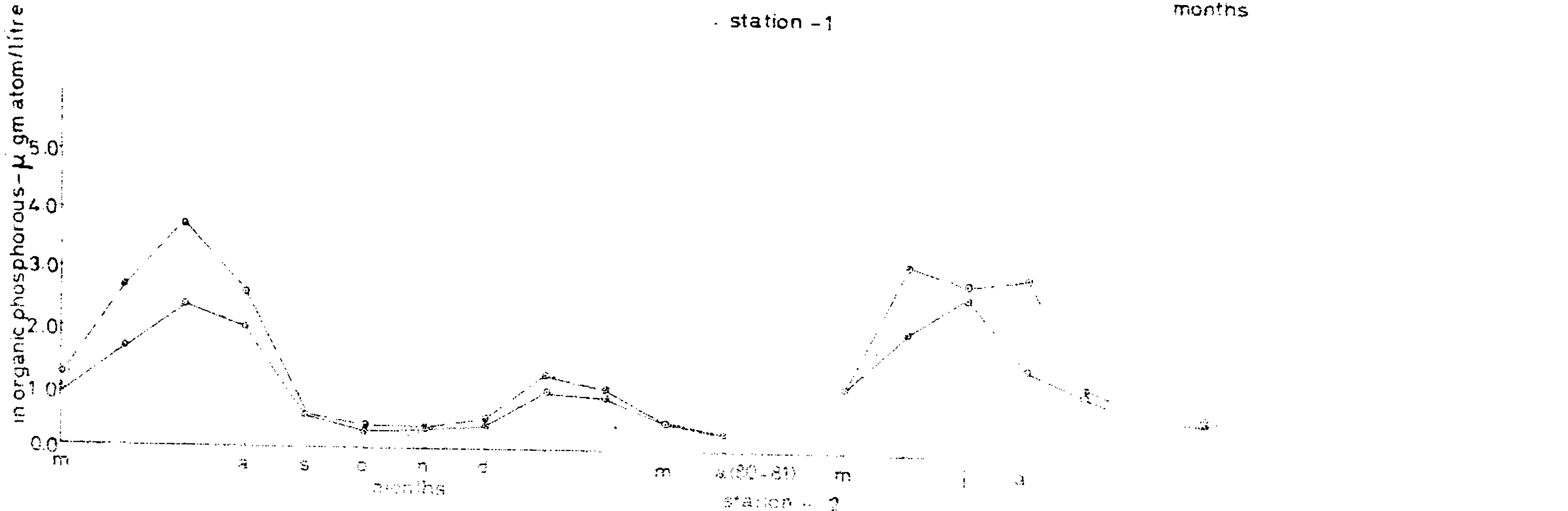



station - 5

fig - 15

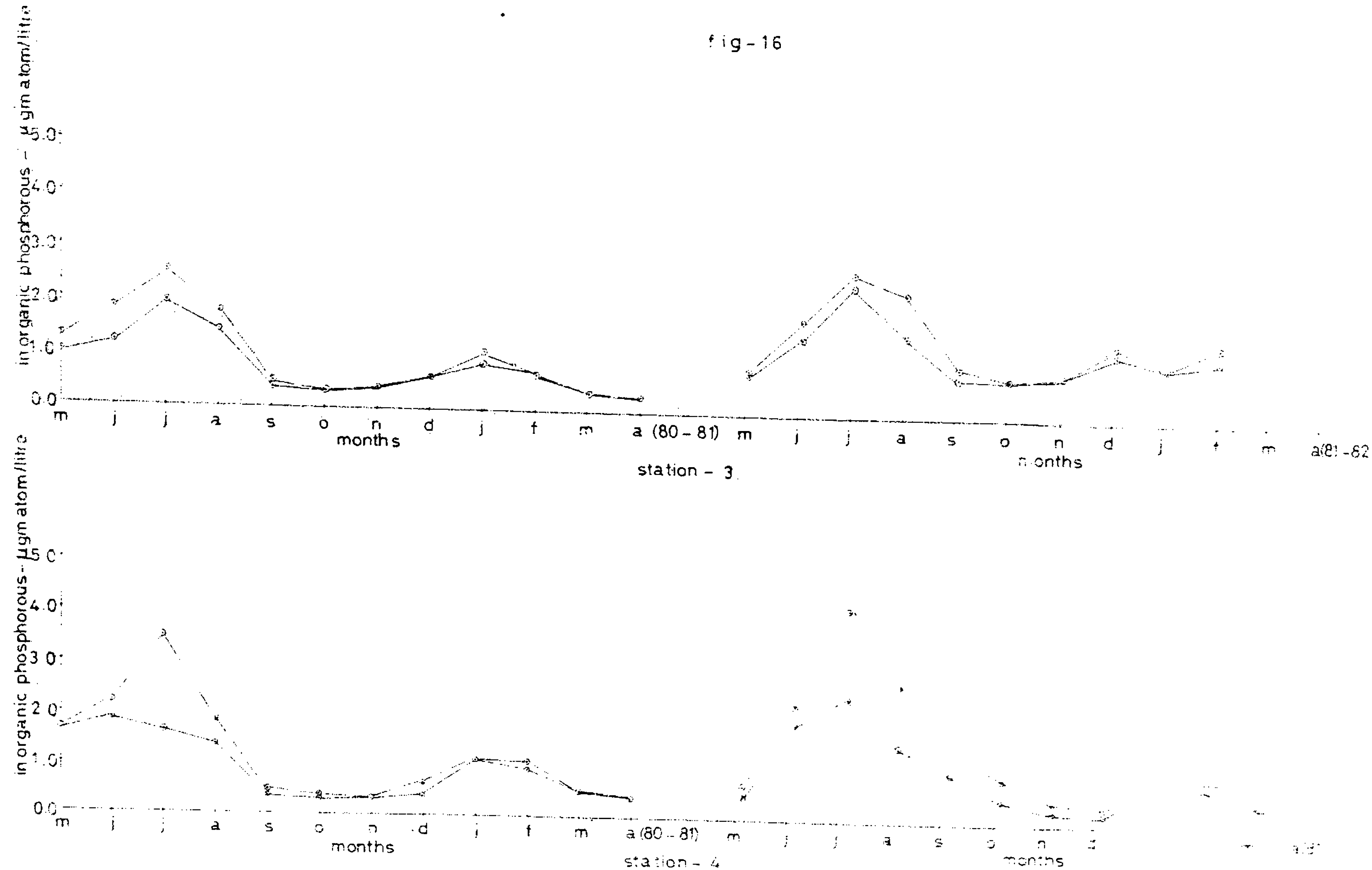


in organic phosphorous - μ gm atom/litre
5.0
4.0
3.0
2.0
1.0
0.0
m
j
j
a
s
o
n
d
j
f
m
a(80-81)
m
j
j
a
s
o
n
d
j
f
m
a(81-82)
months
months
station - 1

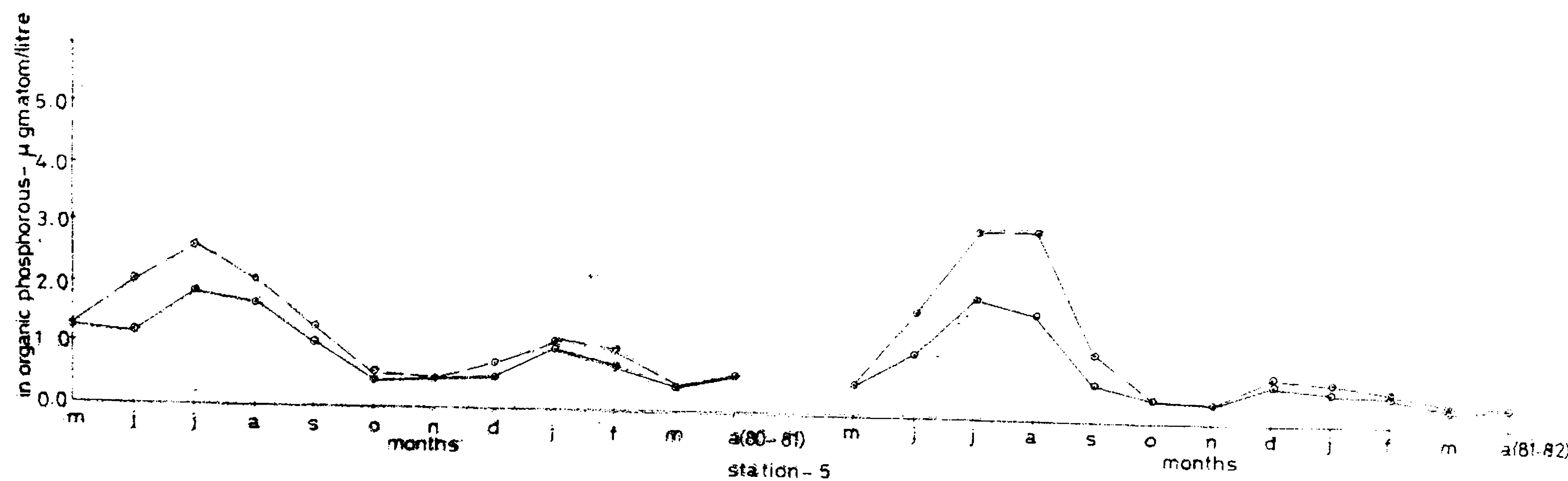
in organic phosphorous - μ gm atom/litre
5.0
4.0
3.0
2.0
1.0
0.0
m
a
s
o
n
d
m
a(80-81)
m
j
a
months
station - 2

fig - 16



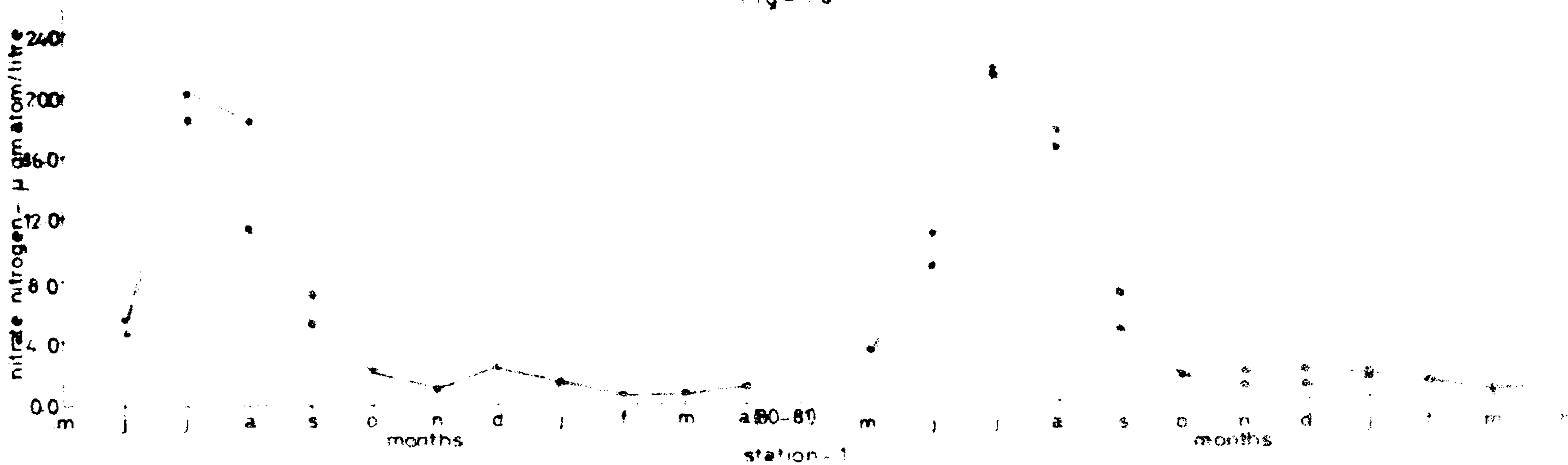
in organic phosphorous - µgm atom/litre
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a (80 - 81) m j j a s o n d j f m a(81 - 82)
months
months
station - 3
in organic phosphorous - µgm atom/litre
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a (80 - 81)
months
months
station - 4

fig -17

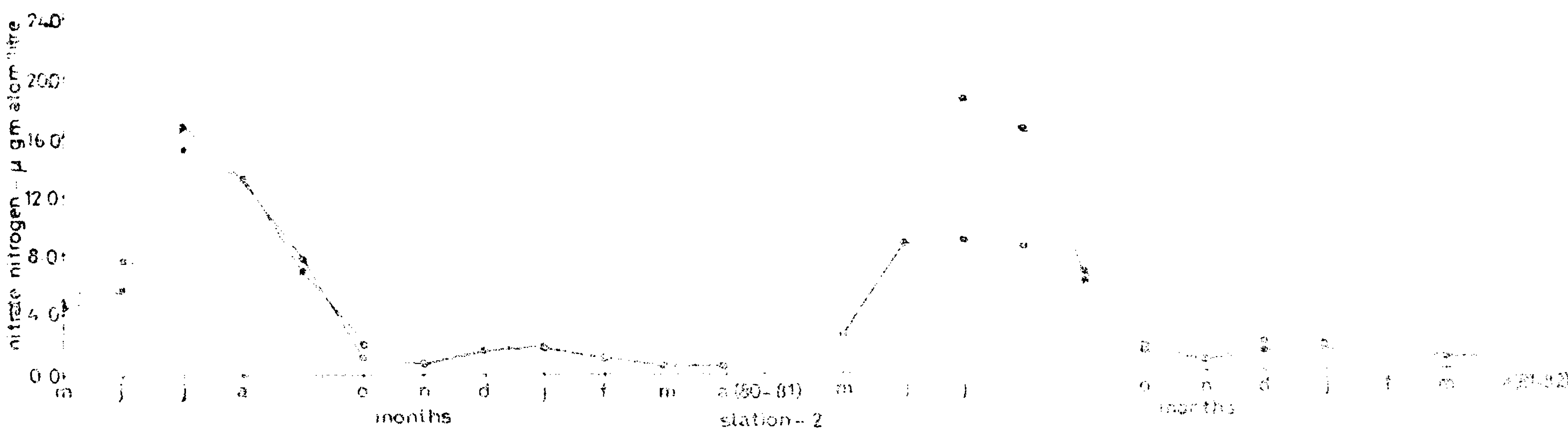


in organic phosphorous - μ gmatom/litre
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a(80-81)
months
m j j a s o n d j f m a(81-82)
months
station - 5

fig - 18

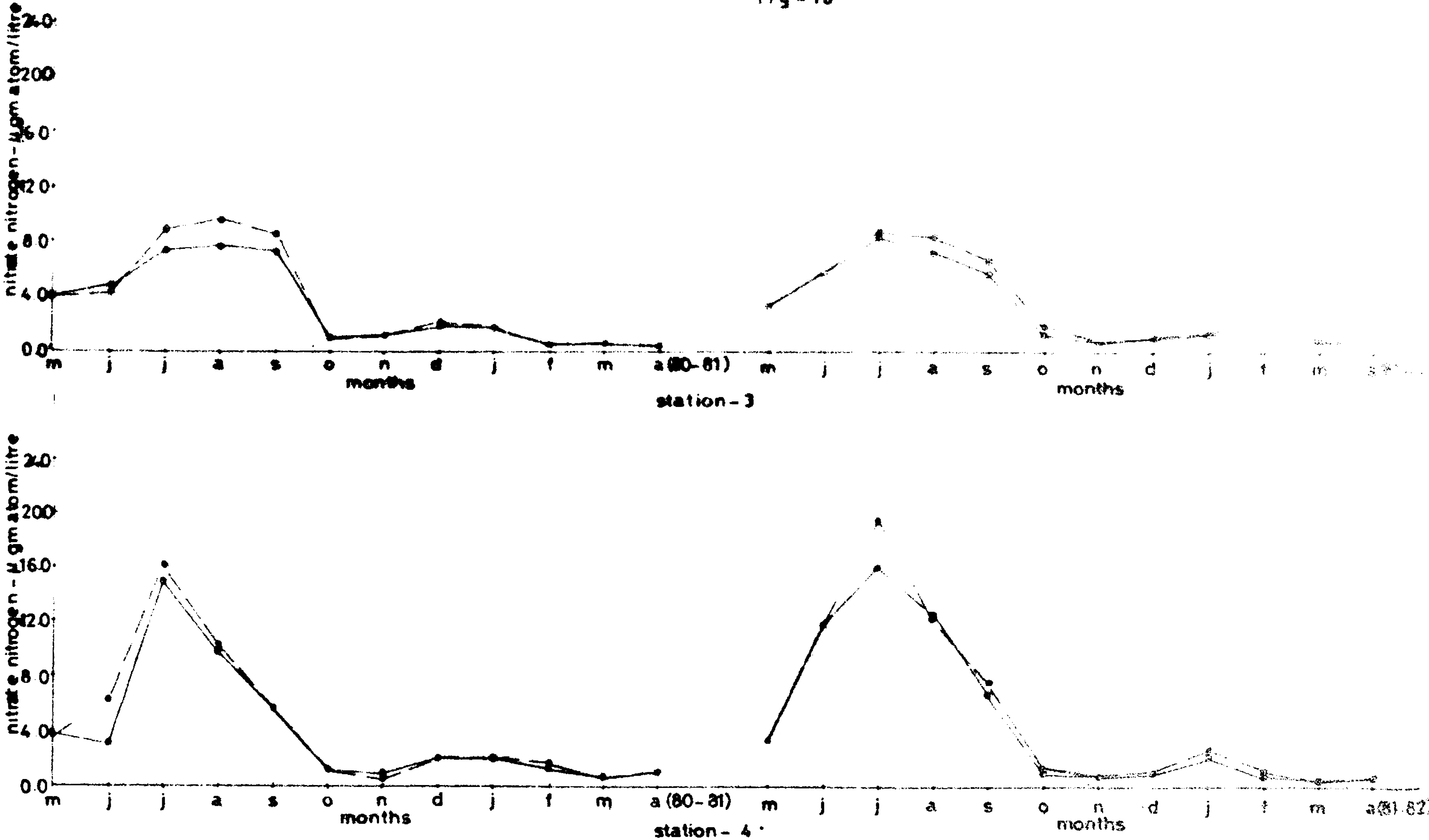


nitrate nitrogen - µ gm atom/litre
24.0
20.0
16.0
12.0
8.0
4.0
0.0
m j j a s o n d j f m a (80-81) m j j a s o n d j f m
months
station - 1

nitrate nitrogen - µ gm atom/litre
24.0
20.0
16.0
12.0
8.0
4.0
0.0
m j j a o n d j f m a (80-81) m j j o n d j f m a (81-82)
months
station - 2

fig - 19



nitrate nitrogen - µ gm atom/litre
0.0
4.0
8.0
12.0
16.0
20.0
24.0
m j j a s o n d j f m a (80-81)
months
m j j a s o n d j f m
months
station - 3
nitrate nitrogen - µ gm atom/litre
0.0
4.0
8.0
12.0
16.0
20.0
24.0
m j j a s o n d j f m a (80-81)
months
m j j a s o n d j f m a (81-82)
months
station - 4

fig-20

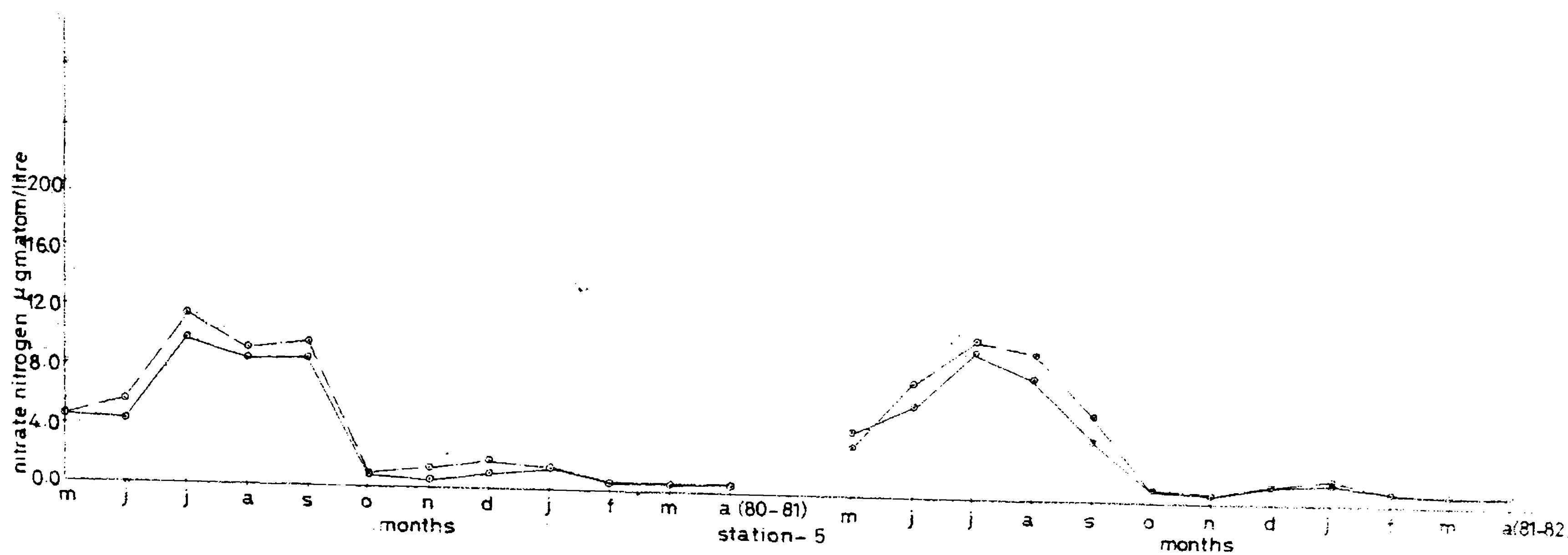
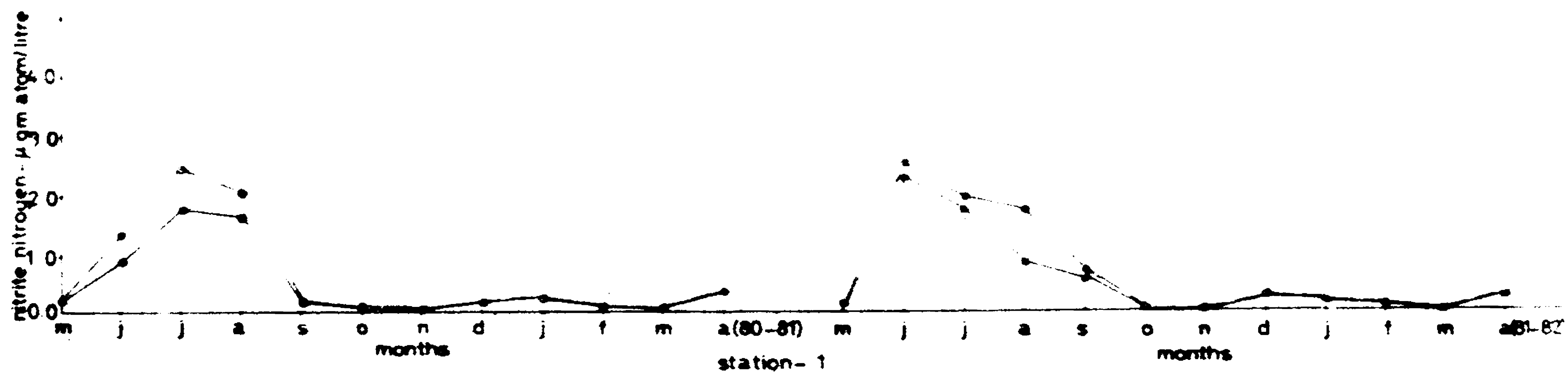

nitrate nitrogen µ gmatom/litre
0.0
4.0
8.0
12.0
16.0
20.0
m j j a s o n d j f m a (80-81)
months
station- 5
m j j a s o n d j f m a(81-82)
months

Fig- 2


nitrite nitrogen - µ gm atom/litre
0.0
1.0
2.0
3.0
4.0
m j j a s o n d j f m a(80-81) m j j a s o n d j f m a(81-82)
months
station- 1
months

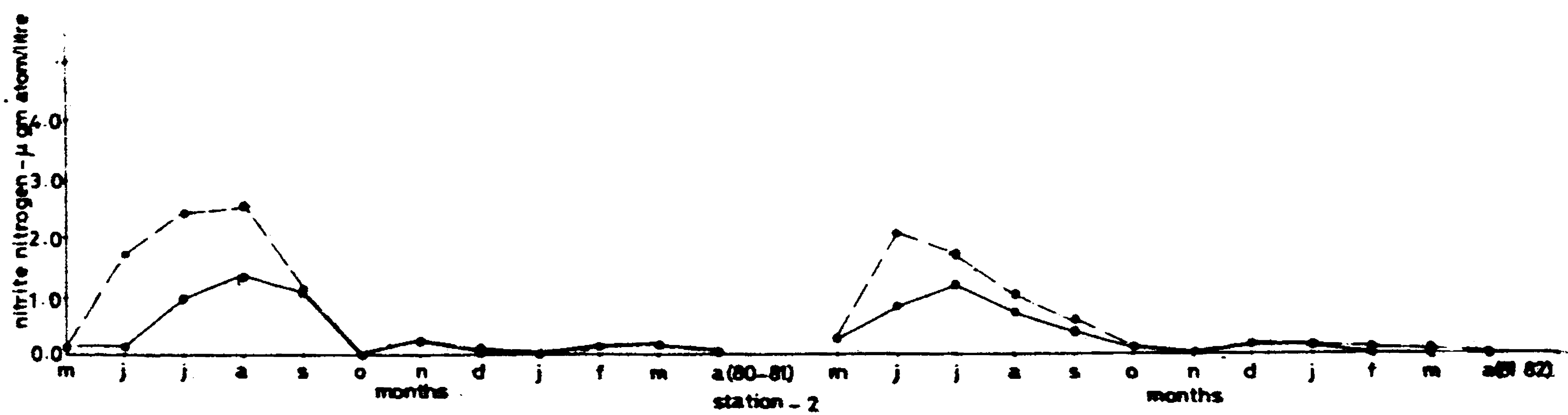

nitrite nitrogen - µ gm atom/litre
0.0
1.0
2.0
3.0
4.0
m j j a s o n d j f m a(80-81) m j j a s o n d j f m a(81 82)
months
station - 2
months

fig- 22

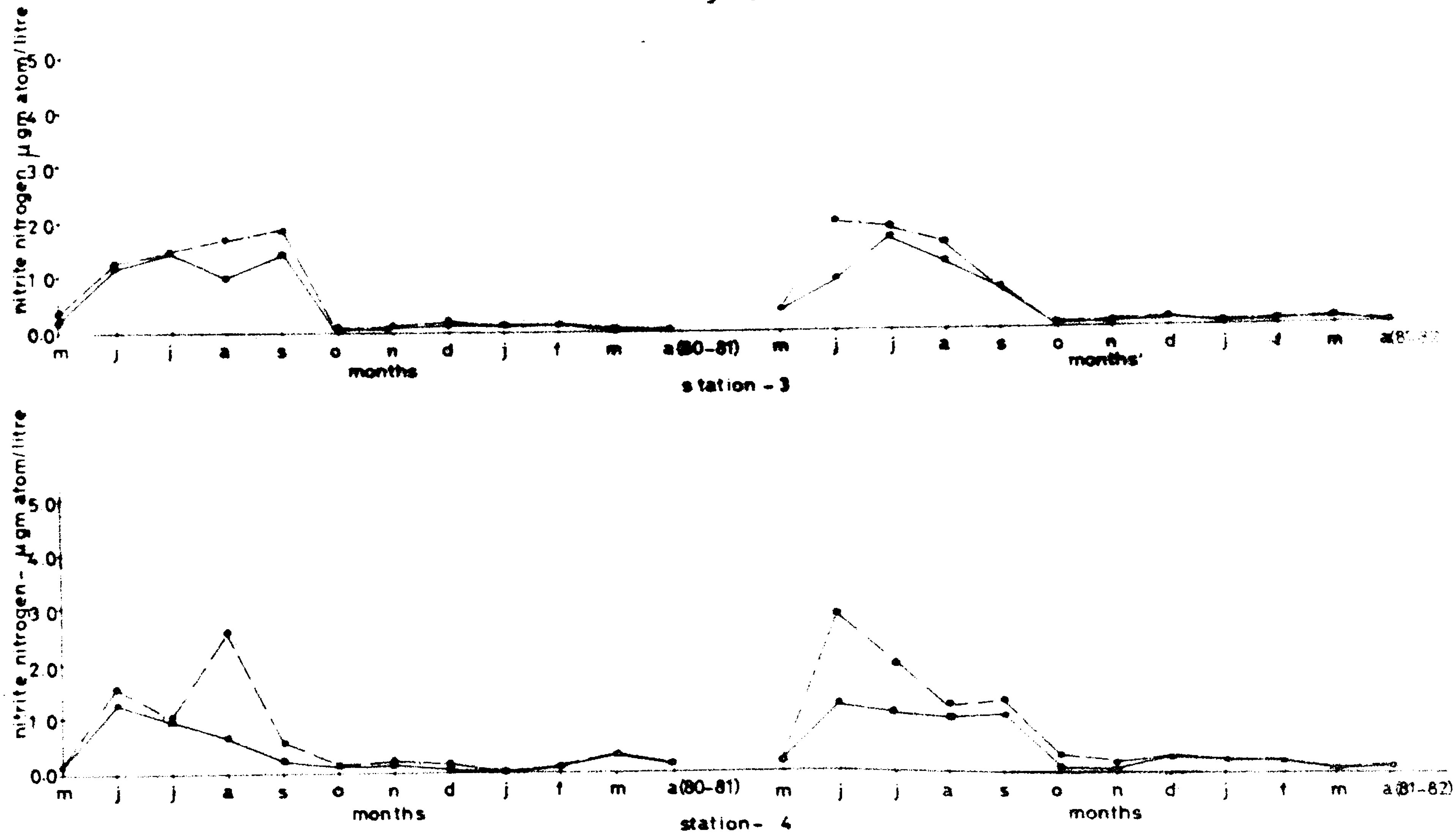

nitrite nitrogen μgm atom/litre
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a(80-81) m j j a s o n d j f m a(81-82)
months
station - 3
nitrite nitrogen - μgm atom/litre
months
station- 4

fig-23

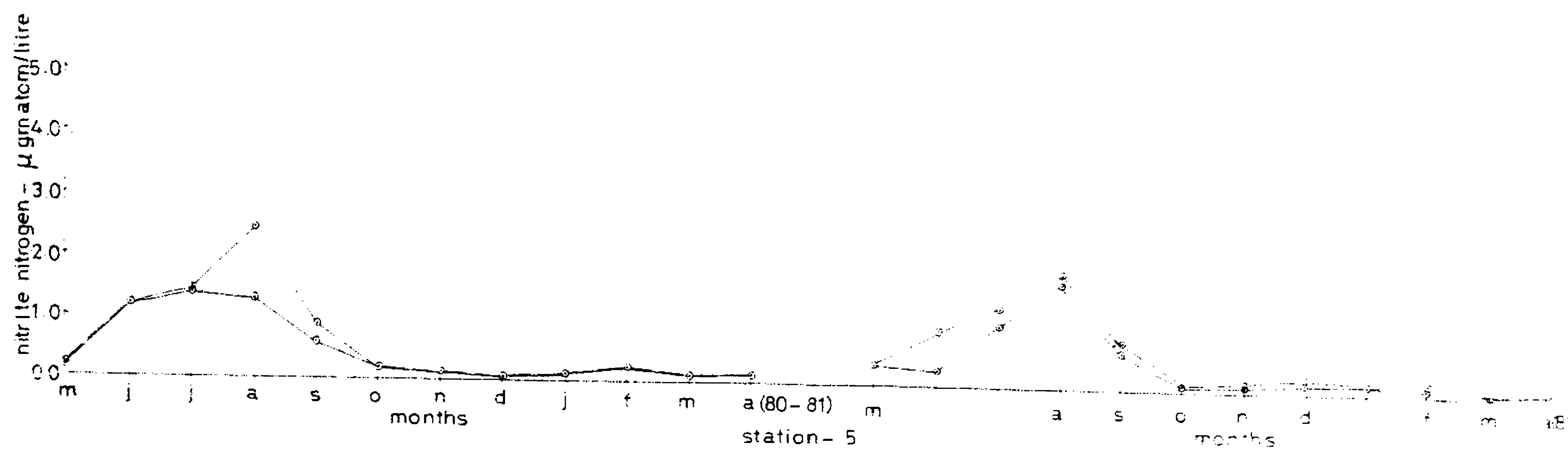
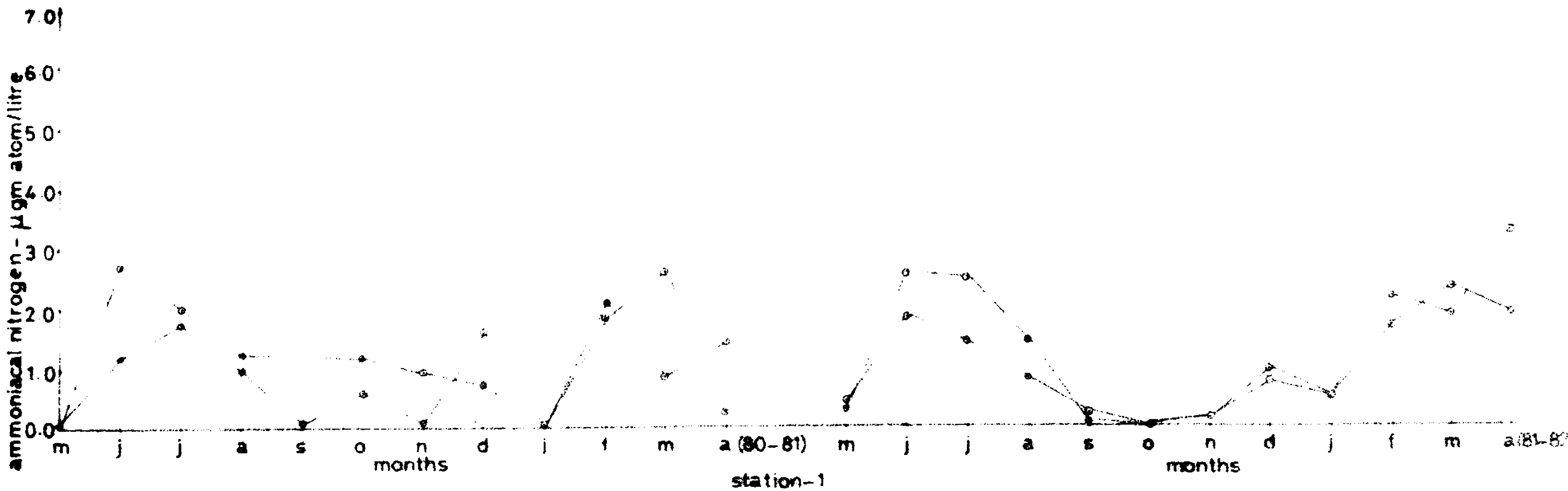
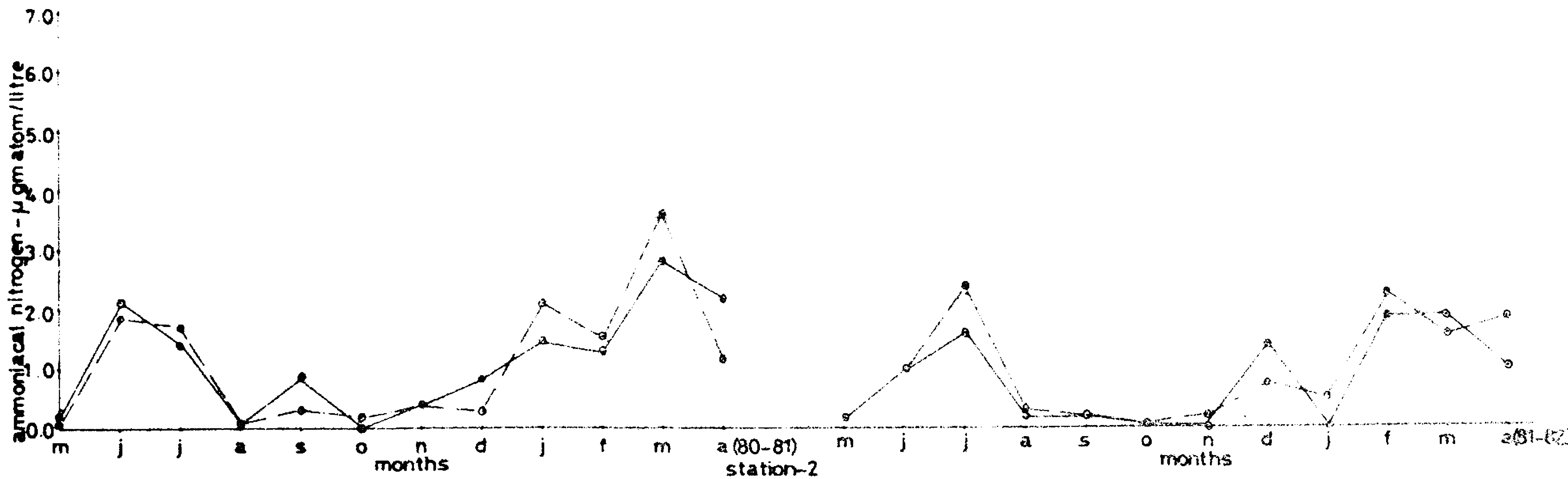

nitrite nitrogen - μ gm atom/litre
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a (80-81)
months
station- 5
m a s o n d f m

fig - 24



ammoniacal nitrogen - µgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a (80-81) m j j a s o n d j f m a(81-82)
months
station-1

ammoniacal nitrogen - µgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a (80-81) m j j a s o n d j f m a(81-82)
months
station-2

fig - 25

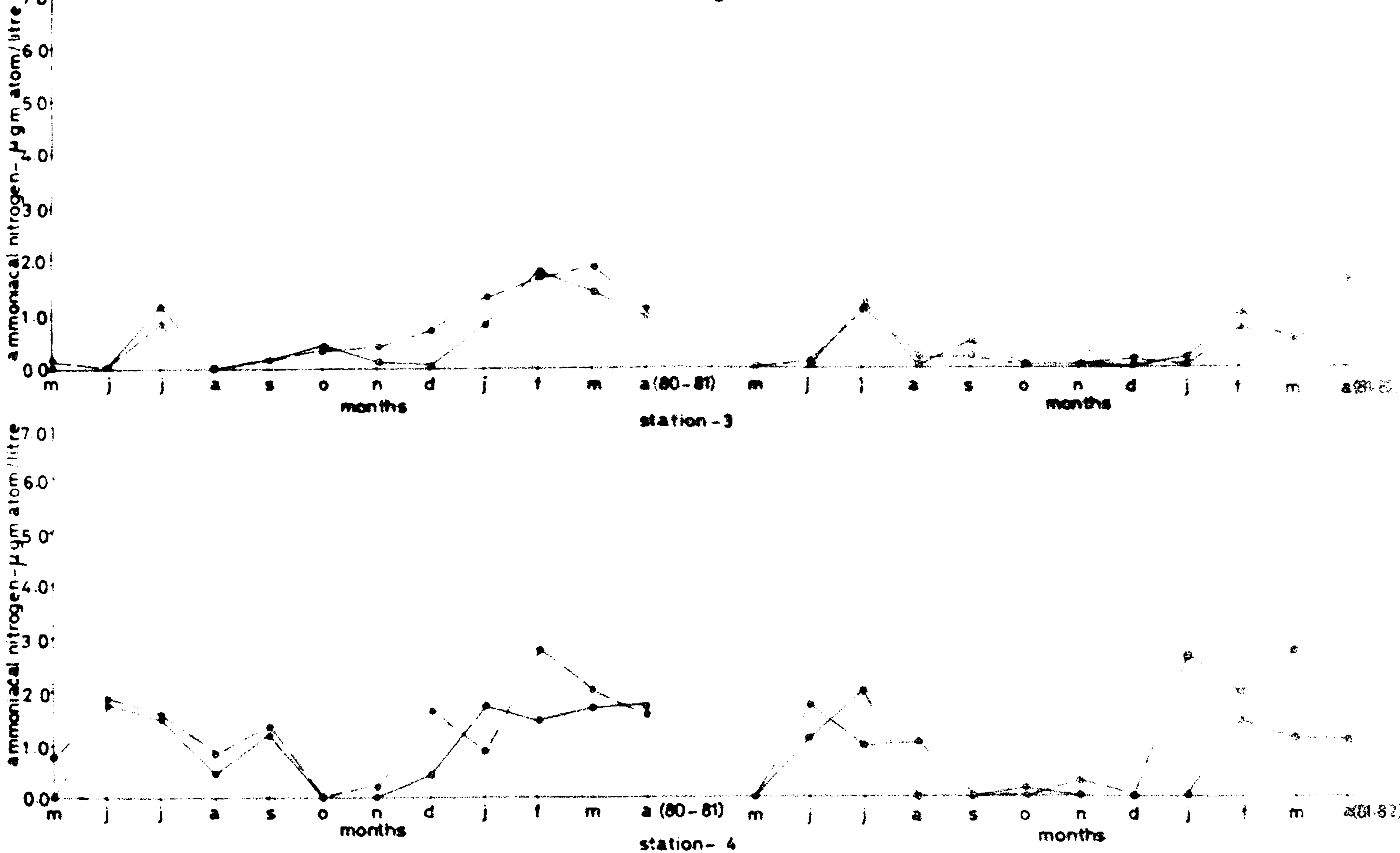
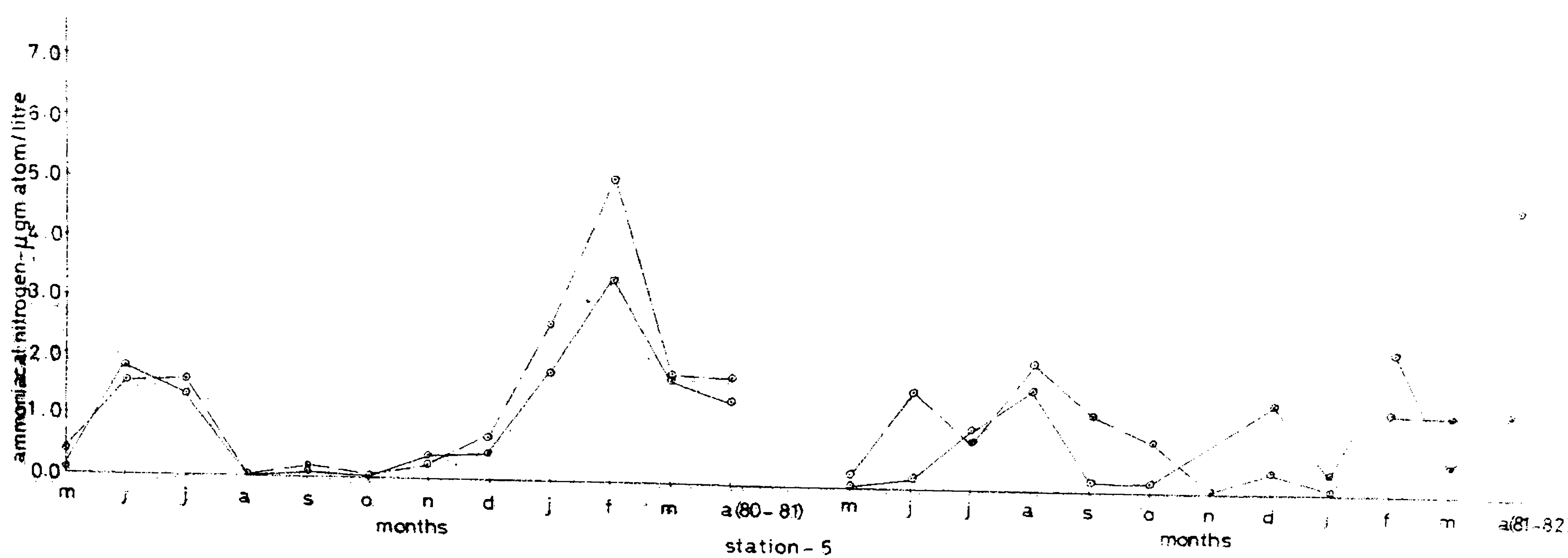

ammoniacal nitrogen- μ gm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
m
j
j
a
s
o
n
d
j
f
m
a(80-81)
m
j
j
a
s
o
n
d
j
f
m
months
station - 3
ammoniacal nitrogen- μ gm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
m
j
j
a
s
o
n
d
j
f
m
a (80 - 81)
m
j
j
a
s
o
n
d
j
f
m
a(81-82)
months
station- 4

fig-26



ammoniacal nitrogen-μgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
m j j a s o n d j f m a(80-81)
months
m j j a s o n d j f m a(81-82)
months
station-5

# CHAPTER-IV

# CRAB FISHERY OF INDIA

## INTRODUCTION

Crabs, the most fascinating animals among decapod crustaceans, occupy a variety of habitats like marine, estuarine, fresh water and terrestrial. More than 5,000 species of crabs are known today. Despite such a vast number, hardly 0.5 per cent is commercially fished all over the world for human consumption. This is primarily because a vast majority of crabs are either too small in size or poor in number at any particular locality to make crab fishing economically viable (Joel and Raj, 1980).

India with a coastline of 6100 Kms. support good crab fishery along its east and west coasts. In addition to this, the numerous backwater systems, estuaries and lakes also are rich sources of crabs. Since 1890, about six hundred and eighty species of crabs have been recorded from Indian waters. Out of this, 14 species including seven marine, four brackish water and three fresh water, are eaten in various parts of the country. Most of the edible crabs caught from the marine and brackish water environs belong to the family Portunidae. According to Rao *et. al.* (1973), only eight species contribute significantly to the fishery. These include *Scylla serrata* (Forskal) *Portunus sanguinolentus* (Herbst) *P. pelagicus* (Linnaeus), *Charybdis cruciata* (Herbst),

C. annulata (Fabricius), C. natator (Herbst), Matuta lunaris (Forskal), and Varuna litterata (Fabricius). But at present, only P. pelagicus, P. sanguinolentus, S. serrata and V. litterata are commercially exploited in our country (Joel & Roy, 1980).

Despite the rich species diversity and abundance of crabs in Indian waters, the fishery is not an organised one even today. This may be because the fishery is seasonal and not much attention is given to the proper development and management of crab fishery. But in the opinion of Rao et al. (1973), in our country, crabs are generally considered as cheap food, consumed mostly by the coastal inhabitants and do not fetch high price as other edible crustaceans and fishes and this is the reason for the scattered and unorganised nature of existing fishery.

Investigations on various aspects of the crab fishery in India was started as early as 1930. Some of the noteworthy works are those of Rai (1933), Hora (1933, 1935), Chopra (1936, 1939), Prasad and Thampi (1951, 1953), Jones and Sugansigari (1952), Menon (1952), George and Nayak (1961), Chhapgar (1962), Pillai and Nair (1973) Rao (1973) Dhawan et al. (1976) and Radhakrishnan (1979). These works include various aspects like ecology, breeding, species composition, fishing methods, seasonal abundance and marketing.

HABITAT AND DISTRIBUTION OF COMMERCIALLY IMPORTANT CRABS

*Scylla serrata* (Forskal)

Known as the mangrove or mud crab, *S. serrata* is a ubiquitous inhabitant of mangrove estuaries and coastal waters. It constitute important fishery in Pulicat Lake, Chilka Lake, Ennur, Corelong and Vembanad Lakes. It is also fished from Gangetic delta.

*Portunus sanguinolentus* (Herbst)

Known as the three spot crab, it is distributed along the marine inshore waters. It is caught from the Malabar and Mangalore coasts and also from the waters of Ennur, Pulicat, Porto Novo etc.

*P. pelagicus* (Linnaeus)

Popularly called as the blue swimming crab, *P. pelagicus* is very abundant along the entire coast. It is fished from the entire east coast and also from Mangalore, Mandapam and Chilka Lake.

*Charybdis cruciata* (Herbst)

It is distributed along the entire coast of India and is fished in large numbers at depths of 15-40 metres.

*C. annulata* (Fabricius)

It is seen in the rocky regions of the coast and forms an important fishery along the Malabar coast.

*C. natator*

Seen in the inshore waters *C. natator* is occassionally caught in large numbers. Malabar coast, Pulicat Lake etc. are noted for the fishery of this species.

*Matuta lunaris* (Forskal)

It occurs along both the coasts and is a very common species in the inshore waters of Bombay.

*Varuna litterata* (Fabricius)

This species prefers the intertidal regions of brackish waters. It is very abundant in the sunderbans of Bengal, pools and creeks in Gangetic Delta, estuarine regions of Hoogly and in the Gulf of Mannar and Palk Bay.

FISHING SEASON

A unique feature of crab fishery is its seasonal occurrence which is a deterrent for developing it into an organised fishery. The fishing season begins at different periods in different coastal states. Rao *et al.* (1973) has reported the crab fishery seasons along the coasts of India. Thus in the west coast, the fishing season synchronises along the Kerala and Gujarat coasts. In both these states intense crabbing is done from July to September. In Maharashtra the season commences in August and ends in October while in Mysore the fishing season starts in December and lasts till January. In the east coast, two fishing seasons are there along the Madras coast, one from March to June and the other from October to December. In Andhra the season begins in April and continues upto December whereas in Orissa and West Bengal the fishing season is from April to September.

Though crab fishing is done along all the coastal States in the west coast, most of the catches are from Bombay in the north-west and from Kerala and Karnataka in the south-west. Along the east coast Tamil Nadu brings in the largest quantity though Bengal and Andhra also have significant fishing areas. Considering species diversity, maximum numbers are reported from Kerala and the least numbers from Gujarat. Specieswise, the west coast is more rich than the east coast.

An analysis of the fishing season also reveals some interesting observations. The fishing season is very short (3 months) in the west coast whereas in the east coast it is from 6-9 months. In the west coast, the fishing season coincides with the south-west moon.

The appearance of the fishery along with the south-west monsoon forces us to deduce that the drastic and peculiar environmental changes brought by the intense south-west monsoon do have a vital influence on the crab fishery. The disappearance of fishery in one part and its reappearance in another part also indicates the migratory nature of crabs. Thus a comprehensive investigation on the migration and other biological aspects in relation to the environment will throw much light on the various aspects of the crab fishery like species abundance and species diversity.

## CRAB FISHERY OF COCHIN BACKWATERS

Cochin backwater system is well known for its fishery potential. The abundance and diversity of both fin fishes and shell fishes makes this estuarine complex an important source of protein food and a centre of intense fishing activities. The backwater system also forms the nursery and breeding and spawning area of a number of species of fishes.

The estuarine system with its adjoining lagoons, mangrove biotopes, inter connected canals and river systems is a healthy habitat for a number of commercially important crabs. Sizable quantities of different species of crabs are fished during different seasons. Crab fishing is done by both professional fishermen who are engaged in crab fishing alone and also by other traditional fishermen engaged in the fishing of fin fishes.

COMMERCIALLY IMPORTANT SPECIES

Four species of crabs belonging to the family Portunidae are caught from the backwaters. They are:

1) *Scylla serrata* (Forskal)
2) *S. serrata serrata*
3) *Portunus pelagicus* (Linnaeus)
4) *P. sanguinolentus* (Herbst)

Though in varying quantities, *S. serrata* is fished from backwater system throughout the year. *P. pelagicus* and *P. sanguinolentus* are caught during the dry months when the estuary is dominated by high saline water.

Fishery of *Scylla serrata* (Forskal)

*S. serrata*, the mangrove or mud crab is a ubiquitous inhabitant of mangrove estuaries and coastal waters. It is distributed from eastern Africa to the central Pacific and is mainly found in the Indian and west Pacific oceans having mangroves. *S. serrata* is the biggest among portunid crabs. The large specimens have a carpace width of above 20 cm. and weigh more than a kilogram. The males are noted for the very strong and massive chelae which can weigh almost as much as the body.

*S. serrata* is the largest and strongest of all the Indian crabs (Hora, 1935). Locally known as puzha nandu (river crab) it is the most important estuarine crab that is exploited in sizable quantities from the Cochin backwaters.

SEASON

The fishery of S. serrata in Cochin backwaters is seasonal. The main fishing season is during the south-west monsoon period. Thus with the onset of south-west monsoon the salinity of water decreases and the fishing for Scylla also starts. This season which begins in June continues till September. During the post-monsoon months of October and November, the fishery declines and again recovers during north-east monsoon period. Thus from December to February there is rather intense fishing though the quantity of the catch is less. During the pre-monsoon months the fishery registers the minimum and only isolated fishing is done during this period.

FISHING METHOD

Two groups of fishermen are engaged in crab fishing viz., professional fishermen who are engaged in crab fishing alone and those who go for crabbing during the crab fishing season and do some other works during other periods of the year.

There are a lot of difference in the type of craft used, period of fishing, method of operation etc. between the professional crab fishermen and others. The professional fishermen are brought by businessmen, engaged in the supply of crabs to the processing industries. So they can be deemed as hired fishermen. They are given some amount of money (Rs.500-2000) as advance for obtaining the craft. They are also given accommodation at the expense of their employer. The other group are local people who are not professionals in crab fishing.

Fishing is done on all days except Sundays. The fishermen reach the fishing ground at 4.30 or 5 in the morning and start the operations. The professional fishermen usually goes on fishing till evening while the other group returns with the catch in the afternoon. No crabbing is done during night. Soon after reaching the fishing ground the operation starts. There will be only two people in a canoe. One man pays the baited long line while the other oars the canoe. 20 to 30 minutes after the long line is paid, it is cautiously lifted from one end, not disturbing the crabs which hold on to the bait with the chelipeds. While pulling up the line, the fishermen knows from the variation in the weight of the line, whether there is crab or not. If there is crab, they catch it with the long handled scoop net. The fishermen are thorough with the position of the crab on the long line and they scoop it even without seeing the crab. After lifting individual baits it is again put into the ground. Thus long line operation is a to and fro process from one end of the line to the other. If the catch is very poor the ground is changed.

Crab nets are operated in the fishing grounds during day time. The nets are lifted at intervals of 30 minutes and the crabs are collected.

CRAFT AND GEAR EMPLOYED IN CRAB FISHING

Different types of crafts and gears are used for crab fishing. Hornell (1924) has given an account of the methods of operation of various crafts and gears. Chacko and Palani (1952), Jones and Sujansigani (1952), Prasad and Thampi (1953), George and Nayak (1961) Rao *et al*. (1968), Datta (1973) and JoelRaj (1980) also have reported on the gears employed in crab fishing.

CRAFT

Dug out canoes and plank built boats are the craft used for fishing *S. serrata*. The dug out canoes are used by professional fishermen while the plank built boats are the craft of local people engaged in crab fishing. The dug out canoe known as 'nandu vallam' in local parlance is made by scooping out a single log of large wood. The canoe is usually 5.5 m long with a width of 55-60 cms. and a height of 30 cms. The sides of the canoe are 2 cm. thick and the keep is thicker than the sides.

The plank built boat is made of planks either laced with coir ropes or nailed with brass nails and is 5-6 metres long. Both the boats are driven by two people, one on either end, with the help of two oars. The oar used by professional fishermen are heavy and longer while lighter and shorter oars are used by the local fishermen.

Inside both the canoe and boat, a temporary compartment is made with plaited coconut leaves or sack and is covered with a screen made of split aracnut palm wood laced together with coir rope. It is in this compartment that the crabs are stocked till they are taken to shore.

GEAR

The main gear used exclusively to catch crabs are long line, scoop net and crab net. But crabs are also caught in almost all gears that are used to catch fin fishes. Thus in Chinese dip net, cast net, bag net, drag net, gill net etc. crabs form an ancillary catch along with other fishes. Though the gears used for crab fishing are described by various authors, local modifications are seen.

LONG LINE WITH BAITS

This is the only gear used by professional crab fishermen in Cochin backwaters (Photograph 1) The long line is made of synthetic fibre (nylon) and about 600 m. long. Two floats, usually of thermocole, are tied on either end of the line. Two large stones (about 0.5 kg.) are tied at a distance away from the float. The distance of these stones from the float depends on the depth of the water where the long line is operated. The floats indicate the location of the line and the large stones along with a number of small stones tied at various positions on the line keep the line on the bottom. The baits are tied to the line one at a point, with small pieces of nylon ropes. The distance between two baits are about 3.4 m. A single line carries on an average 175 baits, but the number of baits also vary considerably.

SCOOP NET

This is the gear used to catch the crabs which hold to the bait on the long line. This is a small net attached to an oval shaped iron frame fixed to a long handle (Photograph II) The width of the net is 40-45 cms. with a length of 55-60 cms. The net has got a depth of 30 cms. and mesh size of 1-2 cms. Length of the handle of the net is as long as 2.5 m. but this length varies depending on the depth of the water.

CRAB NET

It is locally known as 'Nandan vala' Two types of crab net are used here to fish S. serrata ie. square type and round type. The square type net usually has a size of 60 x 60 cms. or 65 x 65 cms. (Photograph III) The net is 30 cm. deep at the centre and is mounted on four sides on coir ropes made taut by means of split bamboo frame fixed at right angles. The bamboo frame is made bow like by tying coir or nylon rope from end to end of each piece of bamboo. This frame when placed on a ground have a height of 7 to 9 cms. at the centre. This facilitates the frame to remain at a sufficient distance away from the net. It is on this frame that the baits are tied with nylon ropes. The frame is tied at the centre to a long rope which carries a float at its end. The float may be either coconut husk or thermocole. The rope is sometimes 5-7 meters long indicating that this type of net is used at a fairly good depth also. Fishermen take the net to the fishing ground in canoes or boat and is operated.

The round type crab net has a circular iron from 50-60 cm. in diameter. (Photograph IV). The net is fixed to this frame by lacing the net with a small nylon rope. The mesh size of the net varies, but is usually 1 cm. from knot to knot. Compared to the square type net, the depth is less and varies between 8-10 cm. at the centre. Two nylon ropes tied at right angles on the frame carries the bait. Four nylon ropes tied at opposite position on the frame balances the net. A long rope, 2-3 m. in length is tied to the common knot of the string that balances the net. This rope is attached to a long pole. The round crab net is used in shallow areas near the shore and is operated from the shore.

CHINESE DIP NET

This is used in the backwater to catch fin fishes. When the net is operated during night crabs are also got along with fin fishes and prawns. In the chinese dip net catches, more berried female crabs are seen than in the catches with other type of gears.

CAST NET

Cast net is a very popular gear seen in the backwater to fish prawns and fin fishes. This net also brings in good quantities of crabs as ancillory catches when operated for prawn and fin fishes.

Crabs are also obtained in other types of gears like bag net, gill net, stake net, drag net etc. which are meant for fin fishes and prawns.

BAIT

Any kind of fish can be used as bait. But in the selection of bait, price and availability often influence the choice. In the long line the only bait used is the flesh of eel. Eel is cheap and very common in the rivers. The consistancy of its flesh is another factor for selecting as bait. Thus the flesh will not soon become soft and break up. Ordinarily the fishermen go to catch the eel on Sundays. The skin and head of the eel are removed and is cut into small pieces (3-4 cms.) and is preserved in common salt. A single bait is used for three days. So after a day's fishing, the bait is again preserved in salt and is used again.

In the square type crab net also eel meat is used as a bait, but in the round crab net head of arius is used as bait. Here only fresh bait is used and it is discarded after use.

REGULATIONS

At present crab fishery is a neglected one. There is no regulation to govern the size and conditions of crabs which can be landed and marketed. Small crabs, berried females and soft shelled ones are frequently seen in the catches.

## HANDLING OF CRABS

The crabs caught from the backwaters are put in the apartment made in the canoe. In the process the crabs are not touched with hands, but are directly transferred from the scoop net to the canoe. Some water left at the bottom of the canoe keep the crabs moist. In dry season the crabs are made wet by sprinkling water. After reaching the shore the crabs are packed in sacks soaked in water or wooden boxes and are sold to the mechants.

## COMMERCIAL UTILISATION

The fishermen sell the crab to a local merchant by a pre-arranged agreement. These local merchants sell the crabs in large quantities to the processing factories. Crabs with a carapace width of 9 cm. and above have commercial value. Fishermen get a fixed price for all crabs above 9 cm. This price varies from Re.0.65 to 1 from place to place.

Till recently crabs were sold to the canning factories. But now freezing of crab meat is started. So most of the merchants boil the crab, extract the meat and sell it to the freezing factories. The present price is Rs.24 per Kg. The body meat and claw meat are extracted and packed separately before it is taken to the factory. But there is no price difference for body meat and claw meat.

## DISCUSSION

It is high time we recognised the economic importance of crab fishery and to give due attention to develop it into a well managed and sustainable fishery. For this a thorough understanding of the present status of crab fishery is inevitable. Sufficient reliable information about growth, breeding, distribution, migration and behaviour of crabs are still lacking. Such knowledge provides the only sound basis for regulation of the fishery and effective conservation of the stocks.

The increased demand of crab meat both in the local market and abroad is attracting the attention of both the fishermen and industrialists. Thus in recent years the intensity of crab fishing in Cochin backwaters has tremendously increased. But so far, no attempt is made to boost the catch by applying scientific techniques. Thus fishing is done mainly using the long line. This is not an efficient gear because when the line is lifted, the crabs which will be eating the bait is disturbed and hence there is every possibility of the crab leaving the bait and escaping. It is high time this old and inefficient gear is replaced by some suitable crab traps. This can reduce the labour, save time and increase the catch. In several countries where there are organised crab fishery, crab traps of different types are widely in use. These traps also known as 'pots' are designed to allow entry of crab but it hinders its escape. Thus if such traps are developed to suit the local conditions, the fishermen can leave these baited traps and come back instead of wasting time as in the case of long line operation. Another important plus point of such traps is that the duration of fishing can be increased much. Now fishing is done only during day time and if traps are used, the fishermen can leave the traps in the ground during night and can collect the crabs in the morning.

In crab fishing, bait is the most important thing because the catch depends on the attraction of the bait. It is seen that more crabs are obtained when fresh baits are used. But, as there is no steady supply of fresh bait, the fishermen use salted bait which obviously reduces the quantity of catch. Only one type of bait is always used. Changing the bait and estimating the catch will help to find out more efficient baits which can increase the catch. Edwards (1979) has reported that when working in one ground continuously it is advantageous to change, at intervals, to different types of bait. Development of cheap artificial bait which attracts crabs will be a big boon to fishermen.

The crab fishermen here are an exploited group. They are not getting a reasonable price for the catch. Elimination of the middlemen who buy the crab can considerably improve the economic status of these fishermen.

The method of marketing of crab meat also needs attention. In several countries the claw meat fetches more money than body meat. Thus in France the Cheliped meat is three times costlier than the body meat (Reste et al. 1976) But here, both the body meat and claw meat get the same price. The ripe ovaries is of little demand. Thus ovaries are not taken for processing and is usually sold at a cheaper rate than the meat. But in Taiwan, the ovary is a great delicacy. Identifying such markets can increase the income through separate packing and marketing of claw meat and ovaries.

As there is no reliable data on the quantity of crab landed and yearly abundance of catch, there is no means to assess whether the fishery of S. serrata is an over exploited one or underexploited one. But it is a general complaint of the fishermen that the size of the crabs caught is decreasing in recent years.

This is a sign of over fishing. So regulatory measures are necessary. Unlike the fishery of prawns which is a multispecies one, crab fishery in Cochin backwater is single species. Again main gear used is long line. It is very easy to adopt conservation measures. Formerly when live crabs were sold to canning factories, crabs below 9 cms. were of no demand. But now as freezing of meat is done, the fishermen catch all crabs irrespective of size. Thus, now the catch contains a good quantity of small undersized crabs. This, if not properly regulated immediately will have a devastating effect on the fishery. Similarly, regulations are to be made to prevent the fishing of berried females and soft crabs.

# CHAPTER - V

## FOOD AND FEEDING HABITS

### INTRODUCTION

Though *S. serrata* constitute an important fishery in the Indo-Pacific region and is potential species for aquaculture, information on the feeding biology is lacking. Until 1976 virtually nothing has been published on the natural food of this species. The first report is that of Hill (1976) who gave an account of the food of *S. serrata* collected from Australian and South African waters.

At a time when there is an increasing interest in the aquaculture of *S. serrata*, the lack of information on its food and feeding habits is a serious lacuna for successful culture practices.

So far nothing has been published on the food and feeding habits of *S. serrata* from Cochin backwaters. During the present investigation gut contents were analysed to gain information on the natural food of this crab.

### MATERIALS AND METHODS

The gut contents of 198 *S. serrata* were removed and analysed. The crabs were caught during different seasons and included the size groups from 38 mm. to 154 carapace width. They also included berried females and soft shelled ones. Only those crabs collected using cast net and Chinese dip net were used for gut analysis. Crabs caught by long line or crab net were discarded as they may have eaten the bait used in such gears and hence give erroneous results. The crabs were preserved in the formalin immediately after collection. After reaching the laboratory, the gut was removed, the fullness of the stomach were estimated and the contents either analysed immediately or preserved in formalin and analysed later. The index of preponderence (Natarajan and Jhingram 1961) was the method used for the gut analysis.

## RESULTS

Seventy six percent crabs examined in the present investigation contained identifiable materials in the gut. The gut of 7 soft shelled crabs analysed contained almost 50 per cent of the gut full of molluscan remains. 53% of the crabs caught during night had more than 50% of their stomach full while only 27% of crabs caught during day time had more than 50% of their stomach full. Out of 17 berried females examined, 8 had bivalve remains while the rest had nothing in the gut except sand and mud. According to the index the food items in the gut may be graded as molluscs (41.7%), crustacea (36.2%), fish (9.3%), amphipods and tanaids

(4.3%), polychaetes (3.5%), algae (2.1%) decayed organic matter (1.2%) sand and mud (1.1%) and plant matter (0.6%) In the crabs upto a size group of 100 mm. carapace width and molluscs (50.5%), crustacea (28.3%), fish (11.4%), amphipods and tanaids (3.5%), polychaetes (2.3%), algae (1.8%), decayed organic matter (1.1%), sand and mud (0.7%) and plant matter (0.4%) in the size group above 100 mm. carapace width. Hard shelled mollusc were predominant in this group. Among molluscs, bivalves dominated and gastropods were seen occasionally. The species identified were _Modiolus_ sp., _Sunetta_ sp., _arca_ sp., _Stantella_ sp., and _Villoritta_ sp., were seen. In all cases shells dominated than the flesh. In two cases entire bivalve tissue without shell were seen. Among crustacea prawns predominated and included the flesh, cut into small pieces, antenules, eyes, telsion and appendages. Body parts of crabs were also seen. Fish remains included flesh, bones, scales and vertebrae. In four case the stomach were seen full or to say overfull with only fish flesh and bones and very little sand and mud.

## DISCUSSION

From the analysis of the gut contents of _S. serrata_ it is evident that it is a bottom feeding carnivore feeding mainly on molluscs and crustaceans. Hill (1976), after analysing the gut contents of

S. serrata has described it as a predator of sesile or slow moving benthic macroinvertebrates, chiefly mollusc. In the present study bivalves were the dominant fraction of the gut contents and gastropods were seen only occassionally. This indicates that the diet of the crab is largely dependent upon local availability of prey species, because the Cochin backwaters are noted for its abundant bivalve fishery resources. This observation is supported by that ofHill (1976) who found that the gut contents of crabs caught from South African estuary, where gastropods were common, contained mostly gastropods, whereas the gut contents of the crab from the Australian waters, where bivalves were common contained mostly bivalves. Cochin backwater is a rich nursery for prawns. Metapenaeus dobsoni, Metapenaeus monoceros and Penaeus indicus are the dominant species which constitute a lucarative fishery in the backwaters. The abundance of crustaceans, especially prawns (M. dobsoni and M. monoceros) in the gut contents indicate that in the process of foraging for food the crabs frequently encounter theburrowing species like M. dobsoni and M. monoceros. But Hill (1976) has experimentally shown that S. serrata did not catch live penaeids as they are capable of rapid escape movement. The presence of crab remains in the gut indicates that the S. serrata prey upon crabs. The presence of fish remains shows that Scylla preys upon fish also for food. The work of Laughlin (1982) as blue crabs supports this argument. Thus he has reported that the blue crab, Callinects sapidus preys upon mobile fast moving prey such as fishes and shrimps. Dead or incapacitated fishes is eaten by S. serrata. Algae and plant materials were seen in the gut but it is difficult to conclude that S. serrata eat plant material. But Veeranan (1974) has reported that he has maintained small S. serrata (less than 10 gm.) feeding them exclusively on plant diet. Hill (1976) observed the foregent of a juvenile S. serrata full of plant material. Thus the possibility of S. serrata resorting to an ominivorous diet particularly during the juvenile stages cannot be ruled out. But Williams (1982) while investigating the natural food of P. pelagicus conducted that the plant material seen in the gut contents may be ingested accidently as prey were gleaned from among algae and sea grass. The presence of sand and mud in the gut contents indicate that the crabs swallowed it along with other food substances. The amphipodes, tanaids and polychaetes seen in the gut may be caught while digging for bivalves. Williams (1982) has reported amphipods and tanaids in the gut contents of Portunus pelagicus.

From the analysis of gut contents it is evident that S. serrata eats a good variety of food without showing any preference for a particular item. Thus availability of the food is the factor that decides what type of food is taken by the crab. If molluscs are available it sustains entirely on molluscs. Similarly if it gets fish, crab eats it sumptuously. This shows that S. serrata is a fairly opportunistic feeder. But the presence of large amount of molluscan remains in the gut of soft shelled crabs indicates that the crab shows some preference for moluscan food after moulting. This affinity for calcereous material may be because during this period the crab is in need of calcium rich food for hardening the exoskeleton. Williams (1982) reported that in the case of newly moulted crabs, calcerous material may be digested and used in forming the new exoskeleton. Xanthid crabs ingested coralline algae when in post-moult condition and crabs which have eaten coralline algae harden their shell faster than crabs which feed only on red algae (Knudsen, 1959). Ennis (1973) noted a preponderence of calcereous echinoderm remains in stomachs of Homarus americanus during moulting periods. Aldrich (1976) has found star fish ossicles in newly moult spider crabs, Libinia emarginata. This clearly shows that decapods in general have an affinity towards calcium-rich pre-after moulting. A general absence or paucity of food in the gut of berried females is because the great distension of the abdomen by the burden of the eggs render them passive. The experiments carried out by Williamson (1900) on *Cancer pagurus* showed that while carrying eggs, female crabs remained half-burried in the sand, ate little and moved little.

More food in the guts of crabs caught during night shows the nocturnal habit of *S. serrata*. Thus the crab feeds actively during night and may remains less active or burried during day time. Hill (1976) has reported that *S. serrata* spends most of the night either walking over the bottom or stationary but not buried. But Barker and Gibson (1978) has reported that *Scylla* feeds primarily during an incoming tidal period.

Chemoreception plays an important role in the feeding behaviour of decapods. With ablation experiments Hazlett (1971) has demonstrated that the antennules of *Callinectes sapidus* and most other decapods examined function as distance chaemoreceptors. There are two modes of chemoreception in decapod crustaceans, contact chaemoreception and olfaction (Barber, 1961). The dactyles of crabs are known to be sites of contact chemoreception and food can be located by walking over it. The slow movement of *S.serrata* over the bottom may involve this form of searching (Hill, 1978) The food is grasped by *S.serrata* by the Chelipeds. The claws are large and powerful and well suited to crushing hard-shelled prey. Brown et. al. (1979) has reported that the decapod Chelae are polyfunctional. According to Warner and Jones (1976), in crab chelae there is a functional correlation between the mechanical advantage of the closer lever system and the properties of the closer muscle. Thus other things being equal, a muscle composed of short sarcomeres will contract faster than one composed of long sarcomeres (Huxley and Niedergerk, 1954) They also argue that longer saromeres would be capable of producing greater tension. But this ability is also related to such factors as the ratio of action myosin filaments and to the physiology of the stimulatory system and sarcoplasmic reticulum. Ebling et al. (1964) found that gastropods crushed by the chelae of 80 mm. Portunus puber required forces of upto 40 Kg. to break the shells. The molluscan shells seen in the gut of S. serrata in the present investigation were thoroughly crushed by the chelae. Predominance of hard shelled bivalves in the gut of large size group crabs indicated that those with massive chelae ate more hard shelled bivalves when compared to small sized crabs. As the bivalves like Sunnetta and Villoritta are burrowed in mud, Scylla dig for these molluscs. Caine (1974) while investigating on the portunid crab Ovalipes quadulpensis reported that it catches prey from a buried position.

The third maxilliped and madibles exert an important role in theingestion of food. As pointed out by Vonk (1960) malacostracans with a well developed gastric mill do not chew their food with the mouthparts, food chewing being a function of the gastric mill. Baker and Gibson (1978) describing the digestive physiology S. serrata concluded that the basic pattern of digestion shown by Scylla is very similar to that of Homarus. A complete digestive cycle in Scylla occupies about 12 h. As food is ingested it is lubricated by mucoid secretions discharged from the oesophagal tegumental glands. Digestion is extra-cellular and digestive enzymes are synthesised by hepatopancreatic F-cells, which then develop into secretory B-cells prior to releasing the enzymes. Active uptake of nutrients takes places from the midgut lumen.

The predation of S.serrata on bivalves can affect the population densities of bivalve molluscs in the estuary. There are numerous reports to show that decapod crustaceans affect local population densities of bivalves. Thus population of soft clams, Mya arenaria, are preyed upon by the blue crab, Callinectes sapidus, and the green crab, Carcinus maenas (Turner, 1948; Spear and Glude, 1957; Hanks, 1963; Ropes, 1968) Muntz et al. (1965) found that predatory activities of large crabs in British waters were an important factor in determining the distribution of prey species. Blue crabs and mud crabs are known to feed upon mussels (Geukensi demissa), hard clams (Mercinaria mercinaria) and oysters (Crassostrea virginica) (Lunz, 1947; Mackenzie, 1977; Wheatstone and Eversole, 1978; Seed, 1980) Menzel and Hopkins (1955) has reported that the stone crab Menippe mercenaria is an important predator of oysters. The sea scallop, Placopectan magellanicus is preyed upon by rock crabs (Cancer irroratus) (Elner and Jamicson, 1979). Thus an increase in the population of crab will have a negative impact on the molluscan population. During the present investigation it is seen that there were no rich molluscan bed in areas where crabs are fished. Molluscus are collected in large quantities from the parts of the estuary where no crabbing is done. It is reasonable to argue here that the crabs are not invading these rich molluscan grounds because present fishing grounds of S.serrata provides them with sufficient food. Just as the population densities of bivalves are affected by crab population, the distribution of S.serrata is also controlled by the bivalve distribution in the estuary.

# CHAPTER - VI

## REPRODUCTION

### INTRODUCTION:

Among various investigations carried on the biology of invertebrates, studies on the breeding biology is given much attention nowadays. A concerted effort is made in various laboratories to domesticate several commercially important species of prawns and crabs to rear them under controlled conditions. Rapid gonadal development of shrimps through eye-abalation techniques, environmental manipulations, hormonal injection etc. has proved that it is now possible to breed the organisms as and when necessary. This new trend in breeding biology has opened new horizons of aquaculture.

Before trying to breed an animal under the laboratory conditions, it is necessary to have a thorough knowledge about its breeding habits under natural conditions. The breeding habits and breeding season of the organisms vary considerably with the local conditions.

During the present work, the reproduction of S. serrata in Cochin backwaters is studied. So far no complete and thorough investigation of the breeding biology of crabs are conducted in Indian waters. The works of Panikkar and Aiyer (1939), Prasad and Thampi (1953), Chhapgar (1956, 1957), George and Nayak (1961) Krishnaswamy (1967), Rahman (1967), Chandran (1968), Pillai and Nair (1971, 1973 a 1973 b) give some information on the breeding of different species of crabs from different areas.

Report on the breeding biology of S.serrata from Indian waters is very sparse and incomplete. The works of Naidu (1955), Pillai and Nair (1973) and John and Sivadas (1978, 1979) bring out some aspects of the breeding of S.serrata. Reports from other countries include that of Arriola (1940), Ong (1966), Brick (1974) and Hill (1975).

## MATERIALS AND METHODS:

Male and female S.serrata were collected from Cochin backwaters to study the breeding habits. The crabs were collected from professional fishermen engaged in crabbing. Berried females were collected from dip net collections, crab net and cast net operators. The size of the crab was taken by measuring the carapace width. Maturity in male was assessed by examining the conditions of the testis. In mature male the testis are swollen. Maturity in the female was recognised by the presence of eggs on the abdomen and the ripeness of the ovary. Thus in a fully mature female, the carapace will be full of ripe, bright red gonad material.

Mating behaviour and pre-moult and post-moult attendance was observed by bringing the crabs got in doubler positions to the laboratory and keeping them in sea water in fibre glass tanks. The salinity was always kept at 28 ± 1%.

The number of eggs were calculated as follows. The pleopods with the eggs were removed and the water was wiped with a belting paper and weighed. From the weight, theweight of pleopods were substracted. Then the number in a small wt. of eggs was counted and from this the total number of eggs were calculated.

## RESULTS

### SIZE AT MATURITY:

Male crabs belonging to different size groups were examined for the presence of ripe vasa deferentia. From the observations it was found that male crabs with a carapace width of 112 mm. or above are sexually mature. Thus in male S.serrata the puberty moult has been achieved when it reached a carapace width of about 115 mm.

In females, sexual maturity was found attained in smaller size groups when compared to the males.

Carapace full of ripe bright red gonadal material was found in females with a carapace width of 104 mm. and above. But in the present study, the minimum size of ovigerous female was found to be 125 mm. carapace width. Maximum number of ovigerous females were found in the size group 135-145 mm. carapace width. The number decreased in smaller crabs and larger ones.

BREEDING SEASON:

Berried females and females with egg remains in the abdomen and those with ripe gonadal material were obtained in all the mouths. During post-monsoon and monsoon periods the number of berried females increased with the maximum in January/February. (Table II) But during the monsoon period the number of berried females were very less even though percentage of large sized females were high.

MATING BEHAVIOUR:

In S.serrata 'premating embrace' was invariably noticed. During this attendence period the male positions himself on the back of the female. This premoult attendence lasts until the female crab moults. The duration of premoult attendance was found varying from five days to as long as sixteen days.

Copulation occurs between a soft-shelled female and hard-shelled male. The female was impregnated within six hours after moulting. During the act of copulation the female rests on dorsal surface with the male over her ventral side. The abdomen of both the male and female are unfolded. In this position the paired copulatory organs of the male are inserted into the sternal apertures of the female. The copulation is a long process and lasts for about two to three hours. After mating, the male was found attending the female for two or three days.

In all cases when mating occurred, it was found that the male was bigger than the female. When two males were kept with a soft female, the larger male was always found possessing the female. The same male crab was found impregnating more than one female.

SPAWNING

The impregnated females spawned within 1½ to 2 months time. The eggs get attached under the abdomen. The number of eggs varies considerably depending on the size of the crab. The average number varies from 300,000-500,000. These eggs were protected under the abdomen for about a week to 10 days after which the eggs are hatched.

MALE FEMALE PROPORTION

It was found that in the catches female crabs outnumber males. With the onset of south-west monsoon the percentage of female crabs were found increasing (Table IV & V) Thus during July 1982 the percentage of female crabs reached as high as 73.4%. But this percentage steadily decreased from December onwards. In March 1982, the percentage of female in the catch came down to 26.6%

DISCUSSION

In male crabs maturity can be determined by examining the state of gonads. Sexual maturity can also be assessed by observing the secondary sexual characteristics. Thus in mature males as a result of relative growth, enlargement of claw occurs.

As in the case of male it is not possible to assess maturity in females by examining the state of gonads alone as the gonads may still be in the immature state even at the time of mating. In order to overcome this difficulty Edwards (1979) has stipulated that the maturity of female crabs be best identified by the following characteristics.

1) the percentage of eggs on the abdomen
2) the presence of sperm in the spermatheca
3) the ripeness of the ovaries.

Butler (1960) while studying the maturity and breeding of Pacific edible crab <u>Cancer magister</u> Dana

This assumption is based on the observation that all the crabs caught in the doubler position was above 120 mm. No crabs were caught in the copulating position as crabbing is done here with long line. But Hill (1975) has reported that while investigating on S. serrata, on three occasions copulating crabs entered the trap.

Very little is known about the development of sperm in crabs. Pearson (1908) has described how the spermatozoa produced in the testis collect in the vas deferns in groups and become surrounded by a capsule to form a spermatophore. Electron microscopic studies carried out by Edwards (1965 a) has shown that mature sperm taken from impregnated females had a 'head' and 'tail' typical of the 'true sperm'.

The presence of females with ripe, carapace full of bright red gonad material and berried females in the estuary throughout the year suggests that S. serrata has protracted breeding habits. Acclerated breeding activity was observed during the post-monsoon and premonsoon periods with the peak in January/February. Pillai and Nair (1973) while investigating the breeding biology of the crabs from the south-west coast of India also found the maximum percentage of ovigerous females in January. Reste (1979) reported two maxima for S. serrata in the bay of Ambaro, one in the dry season

(July-August) and the other in the humid season (January). According to Stephenson (1934) species inhabiting the tropical waters may exhibit several types of breeding cycles, ie. continuous breeding around the year, discontinuous breeding in relation to lunar phases during greater or shorter period in a year, two spawning periods and lastly one single breeding season. Works of various authors on other species of crabs suggests that the breeding season of crabs very much. Boolootian *et al*. (1959) has reported that in the temperate regions the crabs *Hemigrapsus nudus*, *Pachygrapsus crassipes* and *Emerita analoga* seem to have a single breeding cycle. Stead (1898) considered the spawning season of *Neptunus* in Australian waters to be about August to November and Thomson (1951) found the egg bearing season to be from September to April. *Petrolisthes cinctipes* and *Pugettia producta* occurring along the west coast of United States (Boolootian *et al*. 1959), and *P. pelagicus* occurring in Bhatavia breed throughout the year (Delsman and De Man, 1925), Rahman(1967) has reported three definite peaks in the gonadal and hepatic indices occurring in *P. pelagicus* in the months of November, January and in the June-August suggesting an intense breeding activity during these seasons. Pillai and Nair (1973) found the peak for ovigerous females of *P. pelagicus* in January and in the case of *P. sanguinolentus* in February.

Mating behaviour in crabs varies considerably. Hartinoll (1968) has stated that in certain groups mating occurs when both the male and female are hard shelled while in some other groups mating is possible only between a hard shelled male and a soft shelled female. Thus in Portunidae copulation occurs when the female is in the soft-shelled condition.

In S. serrata the premoult attendance of female by the male shows that there is a strong affinity or attraction between the sexes. This is evident from the observation that during the premoult attendance the male did not care for food and the female was always cautious to keep the attending male in position astride her back. But the method by which the male select the partner is not fully understood. Veillet (1945) reported that in Carcinus the recognition of premoult female is by tactile and chemical stimuli on contact. But according to Carlisle and Knowels (1959) the attraction between the sexes is chemical. Thus some time before the moult of copulation the female is exuding a substance (pheromone) which is attractive to the male and can be detected by the male at a distance. But nothing is known about the control behaviour and production of this attractive substance. The great variation in the number premoult attendance days in the same species arises doubt whether such a chemical attractant is produced by the female to attract the male. Ryan (1966) found that in P. sanguinolentus, water in which premoult females had been kept elicited searching behaviour in males whereas water in which intermoult females had been kept did not. Further study indicated that a pheromone is released in the urine of the female. There is not much significance for the number of days of premoult attendance. But this period can last from a few days to a few weeks. Thus Edwards (1966) has reported a premoult attendance of 3-21 days in C. pagurus. At the time of moulting the attending male leaves the female to moult herself. Edwards (1966) has found male C. pagurus assisting the female during moulting.

Mating occured during night. The male always hesitated to mate at the slightest disturbance. Hence it was not possible to observe how he turned the female upside down before copulation. But Edwards (1966) has given a description of the act in C. pagurus. Here, immediately after completing the moult, the female lay as an inert mass, the male being along side her. The male then gently turned the female over onto her back, using his chelae to unfold the abdomen and expose the genital openings. Copulation took place in this instance. During copulation, the male treats the soft female with extreme care and there is every indicating that she cooperates with him during the act. After copulation the male attends the female for a few more days.

In the case of all the crabs caught in the doubler position the male was always above 135 mm. and the female was smaller in size. This may be because that eventhough males attain sexual maturity at 115 mm. carapace width, they may not be actively mating until they reach a carapace width of 135 mm. But from the field observations of Butler (1960) on C. magister, it is understood that two males will fight for a breeding female and invariably the larger male is successful. Polygamy is noticed in S. serrata. Because of this a reduction in the number of male crabs as a result of overfishing or some other reasons will not affect the breeding activity in the population.

Spermatozoa remain viable in the spermatheca until the ova mature. Unless we know the state of the ovary at the time of mating, it is not possible to predict when an impregnated female will spawn. After impregnation the paired female gonads commence development and extend in size until the ripe ovary covers almost the whole dorsal surface of the thoracic regions of the body (Williamson, 1900). He also has reported that in C. pagurus the ovary may not be ripe for a further three months after copulation or in some cases upto 15 months later. Pearson (1908) also supported this view. But in the present study spawning occurred within 1½ to 2 months time. This shows that these females had ripe gonads. John and Sivadas (1979) observed that eye stalk ablation in S. serrata leads to rapid maturation of ovary.

Fertilisation is internal and occurs in the oviduct. The act of spawning was not observed in the present investigation. But in C. pagurus Edwards (1979) reported that during the period of egg-laying, which lasted for about four hours, the crab continually moved her abdomen in an upwards and downwards motion. It appears from the behaviour observed that the female digs out a small hollow into the sand, and this forms a collecting pouch between the body and the curved abdomen into which the eggs are extruded. The extruded ova become attached to the setae of theendopodites of the pleopods. But it is not necessary that all the extended eggs get attached to the pleopods. Ong (1966) observed that, of about two million eggs liberated by S. serrata(Forskal), only 1/3 got attached to the pleopods. The remaining that have been fallen to the aquarium were found to develop and hatch when placed in aerated sea water.

There are various opinions on how the eggs got attached to the pleopods. Williamson (1904) suggested that each egg was impaled on a hair which had been thrust through the external egg membrane. Brockhuysen (1937) while studying Carcinus maenas modified the impaling theory. According to him the egg was passed on to the hair instead of being impaled against it. Yonge (1935) suggested that in Homarus, the eggs were covered with cement at the time of spawning so that they were glued to the setae, which also formed the outer membrane or egg capsule (funiculus). Cheung (1966) could find no evidence of cement glands in the oviducts of Cancer but he believed that the glue was liberated from the egg itself by being squeezed.

The eggs of S. serrata are first orange in colour. As development continues the colour of the egg also changes to red and finally becomes dirty grey. Larval development was not tried in the present investigation.

The sex proportion of S. serrata showed marked fluctuations in the backwaters. Maximum number of females were seen in the catches during the monsoon period. But the percentage of female decreased in the post-monsoon period. Throughout the premonsoon period male crabs dominated the catches. This observation indicates that in Cochin backwaters S. serrata females undergoes breeding migration. The fewer number of females during the summer months may be because the female crabs are migrating to sea for spawning. Arriola (1940) stated that in Philippines, females migrate into the sea to spawn. Ong (1966) reported that, in Malaya, berried females are found in the sea and not in brackish water. Brick (1974) observed that in Hawaii, the females appeared to mygrate from brackish to marine conditions prior to spawning. Hill (1975) also noticed a decrease in the percentage of larger females in South African estuary as a result of breeding migration. He has also reported that populations of S. serrata which do not have access to the sea may not survive.

Salinity appears to be the most important environmental parameter necessary for the hatching of the egg and survival of the larvae of S. serrata. Thus Hill (1974) showed that the first zoeal stage of S. serrata is unsuited to estuarine conditions as they are killed by salinities below 20 ‰. In Cochin backwaters stable salinity conditions occur only during the dry months. At this period the estuary becomes a part of the adjoining sea. It appears that S. serrata spawn in the estuary during this dry months because berried females with dirty-grey eggs ready to hatch were obtained even at 12 Km. upstream the harbour mouth. But during other periods berried females were obtained from near the harbour mouth only.

## TABLE II

## NO. OF BERRIED SCYLLA SERRATA COLLECTED DURING 1980 - 81

| Month | No. of berried females | Average carapace width |
|---|---|---|
| May | 5 | 14.1 |
| June | 2 | 14.6 |
| July | - | -- |
| August | 4 | 13.8 |
| September | 5 | 13.7 |
| October | 3 | 14.3 |
| November | 9 | 13.6 |
| December | 16 | 14.1 |
| January | 31 | 13.8 |
| February | 22 | 14.0 |
| March | 9 | 14.5 |
| April | 7 | 13.4 |

TABLE III

NO. OF BERRIED SCYLLA SERRATA COLLECTED DURING 1981 - 82

| Month | No. of berried females | average carapace width |
|---|---|---|
| May | 7 | 13.8 |
| June | 1 | 15.3 |
| July | 3 | 14.8 |
| August | 3 | 13.9 |
| September | 8 | 13.6 |
| October | 11 | 14.4 |
| November | 6 | 13.9 |
| December | 10 | 13.6 |
| January | 19 | 14.2 |
| February | 26 | 13.8 |
| March | 5 | 14.5 |
| April | 3 | 13.8 |

**TABLE IV**

MONTHLY OCCURENCE OF MALE AND FEMALE CRABS
1980-81

| Month | No. of crabs examined | No. of male crabs | Percentage of male crabs | No. of female crabs | Percentage of female crabs |
|---|---|---|---|---|---|
| May | 186 | 105 | 56.5 | 81 | 43,5 |
| June | 240 | 108 | 45.0 | 132 | 55.0 |
| July | 387 | 137 | 35.4 | 250 | 64.6 |
| August | 193 | 95 | 49.2 | 98 | 50.8 |
| September | 130 | 57 | 43.9 | 73 | 56.1 |
| October | 105 | 55 | 52.4 | 50 | 47.6 |
| November | 148 | 66 | 44.6 | 82 | 55.4 |
| December | 243 | 119 | 49.0 | 124 | 51.0 |
| January | 347 | 216 | 62.3 | 131 | 37.7 |
| February | 216 | 156 | 72.2 | 60 | 27.8 |
| March | 143 | 97 | 67.9 | 46 | 32.1 |
| April | 87 | 49 | 56.5 | 81 | 43.5 |

## TABLE V

### MONTHLY OCCURANCE OF MALE AND FEMALE CRABS 1981-82

| Month | No. of crabs examined | No. of male crabs | Percentage of male crabs | No. of female crabs | Percentage of female crabs |
|---|---|---|---|---|---|
| May | 560 | 273 | 48.8 | 287 | 51.2 |
| June | 860 | 229 | 26.6 | 631 | 73.4 |
| July | 1056 | 353 | 33.4 | 703 | 66.6 |
| August | 472 | 215 | 45.6 | 257 | 54.4 |
| September | 776 | 296 | 38.2 | 480 | 61.8 |
| October | 484 | 224 | 46.3 | 260 | 53.7 |
| November | 520 | 272 | 52.3 | 248 | 47.7 |
| December | 848 | 498 | 58.7 | 350 | 41.3 |
| January | 868 | 573 | 66.0 | 295 | 34.0 |
| February | 660 | 404 | 61.2 | 256 | 38.8 |
| March | 360 | 264 | 73.4 | 96 | 26.6 |
| April | 296 | 156 | 52.7 | 140 | 47.8 |

# CHAPTER VII

## LENGTH WEIGHT RELATIONSHIP AND CONDITION FACTOR OF S. SERRATA

### INTRODUCTION

In crabs the body is completely enclosed in a chitinous exoskeleton. So it is not possible for it to grow continuously as in fishes. Growth occurs only when the exoskeleton is shed. Growth in crabs is, therefore, a combination of moult increment and moult frequency. Moult frequency is more in young crabs and decreases as it grows older.

Several methods are used to study the growth in crabs. In nature it is studied by suture tagging technique. In the laboratory growth is studied by measuring carapace width before and after each moult.

During the present investigation the growth of *S. serrata* is studied using the length (in crabs the carapace width) weight relationship. (In the following discussion wherever the term length is used it implies the carapace width). The condition factor is also worked out to know the monthwise fluctuations in the conditions of the animal.

### MATERIALS AND METHODS

#### Length weight measurements

Length (carapace width) weight measurements of the crab *S. serrata* were taken every month from Station No.3 for two years. To find out the approximate form of relationship between these two characteristics, a rough plot was made, which showed an exponential relation. Hence the model $w = al^b$ was used to represent the relationship. (Details of the equations are given in the Chapter on 'Length weight relationship and condition factor of *P. indicus*') A logarithmic transformation of the variables gave a linear relationship between them. These transformed values of the variables were made use of in order to estimate the unknown parameter of the exponential model.

The goodness of fit of the logarithmic straight lines worked out for all the equations were tested with the help of coefficient of correlation between log weight and log length.

Condition factor

The condition factors were worked out for monthly observations in order to know the monthwise fluctuations of the animal. Fulton's method (Ricker, 1975) of finding out the condition factor was employed using $k=w/l^3$. $k$ was calculated separately for every month and the values then obtained were compared with $a$ values.

## RESULTS AND DISCUSSION

### Length weight measurement

The values of a and b estimated using the least square method are given in Table VI & VII.

TABLE VI

LENGTH WEIGHT RELATIONSHIP OF S. SERRATA

1980 - 81

| | |
|---|---|
| May 1980 | $w = 0.00003821\ l^{3.2560}$ |
| June 1980 | $w = 0.0001442\ l^{3.0230}$ |
| July 1980 | $w = 0.00006533\ l^{3.1820}$ |
| August 1980 | $w = 0.09550\ l^{1.6274}$ |
| September 1980 | $w = 0.001190\ l^{3.0660}$ |
| October 1980 | $w = 0.001211\ l^{2.5506}$ |
| November 1980 | $w = 0.0003359\ l^{2.8533}$ |
| December 1980 | $w = 0.00002059\ l^{3.4250}$ |
| January 1981 | $w = 0.0008445\ l^{2.6541}$ |
| February 1981 | $w = 0.00003941\ l^{3.2993}$ |
| March 1981 | $w = 0.005219\ l^{2.2804}$ |
| April 1981 | $w = 0.00002041\ l^{3.4231}$ |

TABLE VII

LENGTH WEIGHT RELATIONSHIP OF S.SERRATA

1981 - 82

| | |
|---|---|
| May 1981 | $w = 0.03059\ l^{1.9075}$ |
| June 1981 | $w = 0.000009772\ l^{3.5795}$ |

| | |
|---|---|
| July 1981 | $w = 0.0002817\ l^{3.5795}$ |
| August 1981 | $w = 0.0006476\ l^{2.7135}$ |
| September 1981 | $w = 0.1114\ l^{1.6498}$ |
| October 1981 | $w = 0.0001795\ l^{2.9786}$ |
| November 1981 | $w = 0.0001347\ l^{3.5116}$ |
| December 1981 | $w = 0.000\ 3345\ l^{2.8543}$ |
| January 1982 | $w = 0.0001834\ l^{2.9776}$ |
| February 1982 | $w = 0.0009926\ l^{2.6331}$ |
| March 1982 | $w = 0.0001740\ l^{2.9930}$ |

The coefficient of correlations, the A, b, the number of observations n and the level of significance for the crab are given in the Tables VIII & IX.

TABLE VIII

COEFFICIENT OF CORRELATION, THE A, b, NUMBER OF OBSERVATION AND THE LEVEL OF SIGNIFICANCE OF *S. SERRATA* - 1980 - 81

| Month | r | b | A | n | significance level |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| May '80 | 0.9876 | 3.2560 | -4.3178 | 82 | $P < 0.001$ |
| June '80 | 0.9708 | 3.0230 | -3.8412 | 147 | $P < 0.001$ |
| July '80 | 0.9994 | 3.1820 | -4.1849 | 159 | $P < 0.001$ |
| August '80 | 0.9168 | 1.6274 | -1.0200 | 111 | $P < 0.001$ |
| Sept. '80 | 0.9902 | 3.0660 | -3.9247 | 99 | $P < 0.001$ |
| Oct. '80 | 0.9312 | 2.5506 | -2.9171 | 78 | $P < 0.001$ |
| Nov. '80 | 0.9896 | 2.8533 | -3.4738 | 72 | P 0.001 |

| Month | r | b | A | n | Significance level |
|---|---|---|---|---|---|
| Dec. '80 | 0.8864 | 3.4250 | -4.6864 | 80 | $P < 0.001$ |
| Jan. '81 | 0.9538 | 2.6541 | -3.0737 | 81 | $P < 0.001$ |
| Feb. '81 | 0.9835 | 3.2993 | -4.4044 | 87 | $P < 0.001$ |
| March '81 | 0.8889 | 2.2804 | -2.2824 | 76 | $P < 0.001$ |
| April '81 | 0.9793 | 3.4231 | -4.6902 | 31 | $P < 0.001$ |

TABLE IX

COEFFICIENT OF CORRELATION, THE A, b, NUMBER OF OBSERVATION AND THE LEVEL OF SIGNIFICANCE OF S. SERRATA - 1981 - 82

| Month | r | b | A | n | Significance level |
|---|---|---|---|---|---|
| May '81 | 0.8872 | 1.9075 | -1.5145 | 61 | $P < 0.001$ |
| June '81 | 0.9539 | 3.5795 | -5.0104 | 90 | $P < 0.001$ |
| July '81 | 0.9890 | 2.9057 | -3.5802 | 96 | $P < 0.001$ |
| Aug. '81 | 0.9612 | 2.7135 | -3.1887 | 94 | $P < 0.001$ |
| Sept. '81 | 0.5104 | 1.6498 | -0.9529 | 68 | $P < 0.001$ |
| Oct. '81 | 0.9845 | 2.9786 | -3.7460 | 59 | $P < 0.001$ |
| Nov. '81 | 0.9781 | 3.5116 | -4.8708 | 65 | $P < 0.001$ |
| Dec. '81 | 0.9625 | 2.8543 | -3.4892 | 70 | $P < 0.001$ |
| Jan. '82 | 0.9776 | 2.9776 | -3.7366 | 67 | $P < 0.001$ |
| Feb. '82 | 0.7807 | 2.6331 | -3.0032 | 68 | $P < 0.001$ |
| March '82 | 0.9708 | 2.9930 | -3.7594 | 56 | $P < 0.001$ |

Since the correlation coefficients showed very significant values for every month the assumption of linearity between body length and body weight was justified and because of this the linear model for the transformed values was accepted. In most of the cases the *b* values showed a tendency to be very close to 3, which shows that as in the case of fish *b* = 3 can be taken as an indication of isometric growth of the animal.

When the exponent of *l* is 3, the growth can be interpreted as isometric and when it is less than three or more than 3, it can be interpreted as allometric growth. Thus in the crab *S. serrata* both isometric and allometric growth were noticed during the present study. During certain periods of the year the exponent of *l* fluctuated much. Thus in August 1980 and May and Sept. 1981, the values were 1.6274, 1.9075 and 1.6498 respectively. In both the years this rather abnormal fluctuations were noticed during the monsoon period. The reason for this is not known. This is the period when the estuary is dominated by fresh water. But this considerable fluctuation from 3 cannot be attributed to the environmental effects because if such was the case then throughout the monsoon period wide fluctuations would have been seen. In the absence of published work it is not able to compare the present results also.

## Condition factor

The values of k calculated separately for every month is given in Table X & XI.

### TABLE X

CONDITION FACTOR k FOR S. SERRATA 1980-81

| Month | k |
|---|---|
| May 1980 | 0.0001550 |
| June 1980 | 0.0001647 |
| July 1980 | 0.0001521 |
| August 1980 | 0.0003764 |
| September 1980 | 0.0001618 |
| October 1980 | 0.0001608 |
| November 1980 | 0.0001642 |
| December 1980 | 0.0001563 |
| January 1981 | 0.0001574 |
| February 1981 | 0.0001594 |
| March 1981 | 0.0001599 |
| April 1981 | 0.0001840 |

### TABLE XI

CONDITION FACTOR k FOR S. SERRATA 1981-82

| Month | k |
|---|---|
| May 1981 | 0.0001432 |
| June 1981 | 0.0001600 |
| July 1981 | 0.0001675 |

| | |
|---|---|
| August 1981 | 0.0001610 |
| September 1981 | 0.0001617 |
| October 1981 | 0.0001622 |
| November 1981 | 0.0001628 |
| December 1981 | 0.0001607 |
| January 1982 | 0.0001646 |
| February 1982 | 0.0001659 |
| March 1982 | 0.0001682 |

Fulton's condition factor is suitable for comparing different individual fish of the same species. It will also indicate the differences related to sex, season or place of capture. It is most useful, if under average or standard conditions, the exponent b is actually equal to 3 for the species in question. But Fulton's factor can also be used to compare fish of approximately the same length, no matter what the value of b is.

The heavier a fish at a given length, the larger the condition factor and (by implication) the better 'condition' it is in. Based on this the k values obtained were compared with the a values. It is seen that the 'condition' of the crab shifts between poor and better from month to month and year to year. A comparison of the k values with a values show that in the year 1980-81 the crabs were in a better condition than those in 1981-82. In 1980-81 the condition of the crabs were better during the premonsoon and monsoon periods while they were in poor condition during post monsoon period. But no such peculiarity was seen during 1981-82 period.

The poor condition of S. serrata in the backwater may be due to the combined effect of a number of factors like the environmental conditions, availability of food and the state of the organism. The backwater system is an ecologically disturbed one. The toxic effluents reaching the system do have an impact on the natural environment and consequently on the organisms also. But the actual effect of the pollutants and the extent to which it is affecting the different organisms cannot be confirmed without further studies. Reste et al. (1976) have reported that in crabs there is a cyclic filling in and filling out phenomena. Thus crabs caught during the filling out period will be in poor condition. Similarly spent females also will be in a poor condition. Various diseases also will affect the health of the organisms.

Studies on the condition factor will enable us to understand the suitability of the environment in which the organism is living. Thus organisms living in a healthy environment with enough food will be in excellent condition. Lalithambika Devi *et al.* (in press) have reported that, if the length-weight relation is carefully estimated, the condition factor can be a useful index of the quality of the organism and the suitability of the environment for their growth.

# CHAPTER VIII

## SUMMARY

Cochin backwater system is an ecologically disturbed one due to undue interference of human beings and as a result of large quantities of pollutants reaching the backwater.

The estuarine system is highly productive. The hydrography of this estuarine system is controlled by the various meteorological conditions. Thus it is dominated by freshwater during one part of the year while it becomes part of the adjoining sea during the dry months. These changes in the environmental characteristics affect the flora and fauna.

The backwater system is noted for its finfish and shell fish resources. The abundance and diversity of the species indicates the suitability of this water body to support a rich biomass. Among shell fishes the estuarine crab S. serrata forms an important fishery. The fishery of S. serrata is seasonal. Both professional and other fisherman are engaged in crabbing. Fishing is done mainly with baited long line in dug out canoes and plank built boats. Due to lack of any regulations, the crabs are indiscriminately exploited at present. Hence due attention is to be given for the proper management of the fishery.

Present investigation has shown that _S. serrata_ is fairly an opportunistic feeder. The stomach contents varied with the size of the crabs. During certain periods it showed preference for particular food.

_S. serrata_ is a continuous breeder with peak breeding activity in January/February. Variation in the proportion of males and females in the catches shows that the females undertake breeding migrations. Polygamy is noticed in this species. Premoult and post moult attendance by the male are observed. The crab has a very high fecundity rate.

Both isometric and allometric growth are seen. The condition of the crab was found fluctuating from month to month and year to year.

_S. serrata_ is a potential species for culture. It has great adaptive capacity to different environmental conditions. It is fast growing with a high fecundity rate and protracted breeding habits. Vast areas adjoining the estuarine system can be used for culturing this crab.

# P A R T  II

INVESTIGATION ON THE PRAWN

*P. indicus* H. MILNE EDWARDS

# CHAPTER IX

## PRAWN FISHERY OF INDIA

### INTRODUCTION

India ranks first among the prawn producing countries of the world. This prestigeous status of the largest producer of the world's highly esteemed marine food was attained by this country in 1973 and ever since this is being kept up. The prawn fishery of India is mainly constituted by the prawns belonging to the family Penaeidae. Nonpenaeid prawns of the families Palaemonaidae, Hippolytidae, Sergestidae and Pandalidae also contribute to the fishery.

An examination of the prawn landings in various maritime states shows that more than 85% of the marine prawn landings are from the west coast. Along the west coast itself Kerala and Maharashtra account for the bulk of the catch. Along the east coast Andhra Pradesh and Tamil Nadu are the major contributors.

The prawn fishery of India is dynamic and complex and is supported by multiple species that coexist in the same fishing ground. Fifty two species of prawns and shrimps which have great commercial potential occur in the Indian waters (Swaminathan, 1978). Out of this only eight species of penaeid prawns and four species of nonpenaeid prawns contribute to the major portion of the fishery at present. The various penaeid prawns of importance are Penaeus indicus, H. Milne Edwards, P. semisulcatus de Haan, P. merguiensis de Man, Metapenaeus dobsoni (Miers) M. monocaros (Fabricius), M. affinis H. Milne Edwards and Parapenaeopsis stylifera H. Milne Edwards. Of the non-penaeid prawns Acetes indicus H. Milne Edwards, Nematopalaemon tenuipes (Henderson) Exhippolysmata ensirostris Kemp and Exopalaemon styliferus H.Milne Edwards are the dominant species.

Kerala with a coast line of 560 Kms. is rich in its prawn fishery resources. P. indicus, Metapenaeus dobsoni and M. monoceros are the economically important species which constitute the major portion of the landings.

## RESEARCH APPROACH

A review of the voluminous literature on shrimps shows that no other group of invertebrates are so thoroughly and elaborately investigated as shrimps. The various ecological, biological, physiological and bio-chemical aspects of all commercially important prawns are studied in much detail. Investigations are still going on in various parts of the world on artificial fertilisation, larval feed, and pathological aspects. A number of species are domesticated and are used for intensive culture under controlled conditions. Much attention is also given on the genetic aspects for the improvement of the stock.

A scrutiny of the literature on different aspects of P. indicus in prawn culture fields shows that so far no work is done on the length weight relationship and condition factor of this commercially most important species. Though various workers have reported on the food and feeding habits of prawns from their natural habitat, no account of the food and feeding habits of P. indicus in a seasonal and perennial prawn culturing fields are available. Similarly no literature is found on the relationship between the benthic production and food habits of P. indicus. Hence the present work is aimed at investigating the above aspects of P. indicus in a seasonal field and perennial field in relation to the various environmental conditions.

## REVIEW OF PREVIOUS WORK

A review of the previous work on various aspects of prawn culture in prawn culture fields shows that only very little work is done on various aspects. Some aspects of prawn culture practices of Kerala have been dealt with by Panikkar (1937), Menon (1954), Gopinath (1956), Kesteven and Job (1957) and George (1974). All these workers have given more emphasis on the biological aspects of culture and only a little attention was given on various environmental parameters of the culture field. The works of Sankaranarayanan et al. (1982) and Gopinathan et al. (1982) give detailed accounts of the various environmental characteristics of prawn culture fields.

So far no report is seen on the benthic production of prawn culturing fields. Growth of penaeid prawns in India are investigaged by a number of workers and these works are reviewed by Jone (1969) and Mistakidis (1970). Some of the recent works are those of George (1974), George (1975), and Suseelan (1975 a and b). But detailed studies on the length weight relationship and condition factors to understand the dynamics of grwoth are sparse. Hall (1962) studied the condition factor for prawns in Malaysian waters. Recent detailed works on length weight relationship and condition factors are those of Sreekumaran Nair et al. (1982) and Lalithambia Devi et al. (in press).

# CHAPTER X

## ENVIRONMENTAL CHARACTERISTICS OF PRAWN CULTURE FIELDS

### INTRODUCTION

Prawn culture has got more significance today than ever before, because day by day the demand for this high priced and nutritionally rich sea food is increasing while the natural resource is showing signs of depletion. Only way to escape from this predicament is to find alternate methods of production and hence the importance of aquaculture. Several countries have developed techniques for scientific culture of shrimp. India is also a leader in this respect by developing low cost technology for the production of prawns.

In India about 30,000 ha. are used for prawn/fish culture. This includes 20,000 ha. of 'bheries' in W. Bengal, 5120 ha. of Pokkali fields and 800 ha. of perennial fields known as 'Chemmeen Kettu' in Kerala, 2320 ha. of 'gazani' farms in Karnataka and 1800 ha. of 'Khazan' lands in Goa. Pokkali fields of Kerala are low-lying coastal areas where a salinity tolerent variety of paddy called 'Pokkali' is grown during the S.W. Monsoon period and prawns during the rest of the year. In perennial fields prawns are cultured throughout the year. The estimated prawn production of these fields vary from 500-1200 Kg./ha/season. The total production is about 4800 tons. (Alagaraswami, 1981). Perennial fields are larger (upto 100 ha.) and deeper (1-3.5 m.) than pokkali fields with an average catch of 840 kg./ha. (Ramamurthy, 1981).

THE STUDY AREA

The fields selected for the study are situated in the Vypeen island (Fig. 27) Vypeen island is located along the latitude 9°58' - 10°11'N, longitude 76°10' - 76°15' E in the central part of Kerala. It has a length of 25 Kms. and a total area of 69.63 Sq. Kms. and is sandwiched between Cochin backwaters on the eastern side and Lakshadweep sea on the western side. Originating from the main backwater, there are 13 canals, each 10-12 M. wide, running across the island and parallel to each other (George 1974). These large canals together with numerous other inter-connected subsidiary canals supply estuarine water to the prawn culture fields.

Two types of fields, perennial and seasonal, are used here for prawn culture. According to George (1974) 130 ha. of perennial fields and 1040 ha. of seasonal field are utilised for prawn culture.

MATERIALS AND METHODS

A perennial field of 40 ha. and a seasonal field

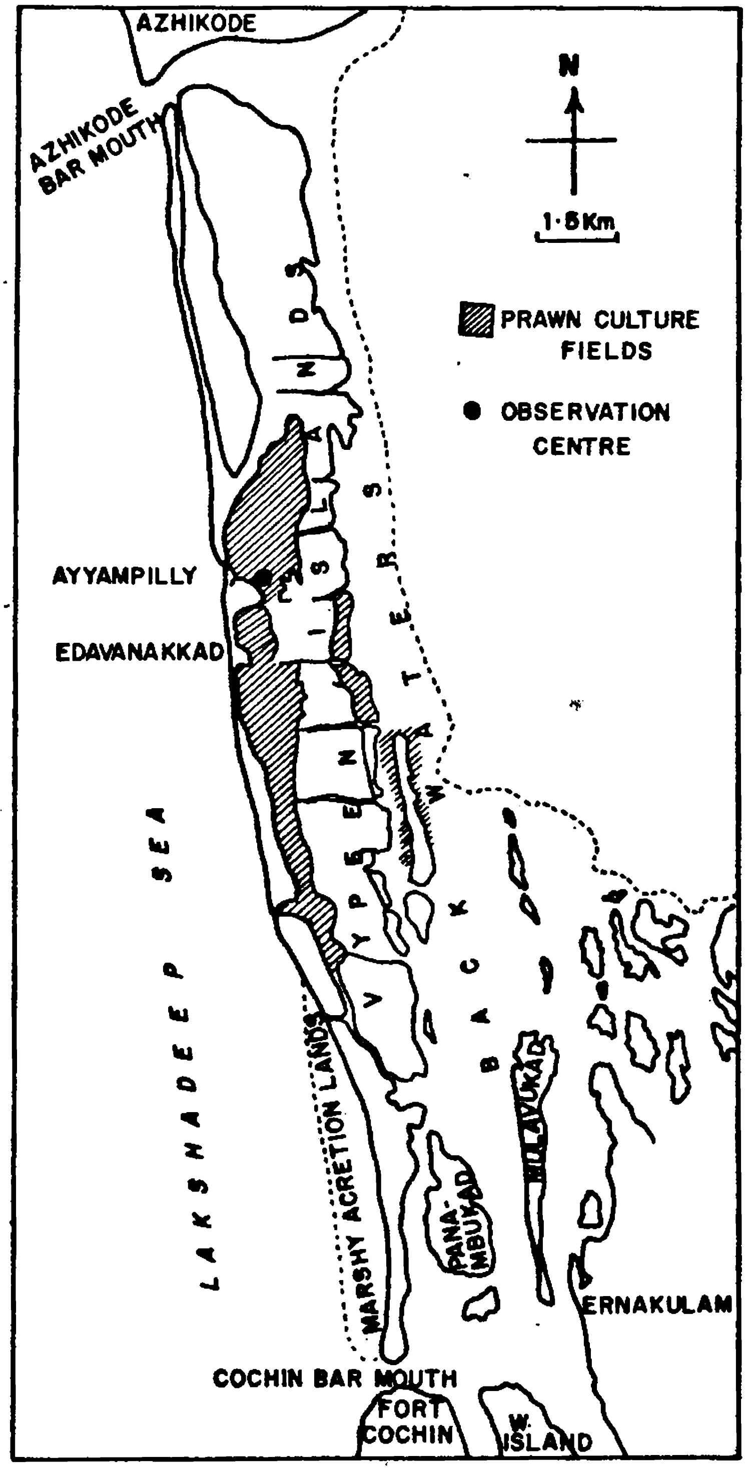



Fig. 27 LOCATION OF PRAWN CULTURE FIELDS IN VYPEEN

of 15 ha. situated about 15 Kms. north of Cochin harbour mouth were selected for the present study. In seasonal field the culture period was from October to April while in perennial field the period was from October to September. Monthly water samples, both surface and bottom were collected from four stations in the seasonal field and eight stations in the perennial field. The different parameters analysed included temperature, salinity, dissolved oxygen, pH, ammoniacal nitrogen, nitrite nitrogen, nitrate nitrogen and inorganic phosphate. The collection of samples and estimation of parameters were done as detailed elsewhere.

## RESULTS

### SEASONAL FIELD

#### Salinity

In October when prawn culture started the field was fresh water dominated. (Fig. 28 & 29) The salinity started to recover in November and reached its peak in April. During this period the bottom salinity were above 28 ‰. No stratification was seen in the water column.

#### Temperature

The distribution of temperature in the surface & bottom water and soil are given in Figs. 30 & 31. In

In all the stations and during all the months the bottom temperature was less than surface temperature. Soil temperature closely followed bottom water temperature but were sometimes less and sometimes higher than the bottom values. Highest temperature (above 33 °C) was noticed in April Like salinity there was also no temperature stratification noticed.

Dissolved oxygen

Monthly distribution of dissolved oxygen in various stations are shown in Figs. 32 & 33. During October the oxygen values were high but the values dropped in November and reached still lower values in December. But higher oxygen values were noticed again in January and February. Oxygen concentration further decreased in March-April. Vertical variation in the dissolved oxygen concentration was negligible.

pH

The pH values of the water column varied between 7 and 8 (Figs. 34 & 35). The pH values were low when the system was freshwater dominated and were higher when saline conditions prevailed in the field. pH of soil also varied from month to month.

Inorganic phosphorus

The distribution characteristics of inorganic phosphate are shown in Figs. 36 & 37. The $PO_4$-P values were found increasing from December onwards and comparatively higher values were obtained till March after which the values decreased. The bottom values were higher than surface values during all the months.

Nitrate-nitrogen

The variations in the $NO_3$-N values during different months are given in Figs. 38 & 39. Higher $NO_3$-N are noticed in December, January and February. But in 1980-81 $NO_3$-N values were higher in March than in February. $NO_3$-N registered its minimum in April.

Nitrite-nitrogen

The $NO_2$-N values for different months are depicted in Figs. 40 & 41. The nitrite values were seen increasing from October and higher values were obtained till February. March onwards the values decreased. $NO_2$-N were higher in the bottom and decreased towards the surface.

Ammoniacal nitrogen

The concentration of ammoniacal nitrogen in different stations during different periods of the prawn filtering season are illustrated in Figs. 42 & 43. The $NH_4$-N values fluctuated from station to station and month to month. The values varied between 0.02 to 4.34 µg at/l.

## PERENNIAL FIELD

Perennial fields are subjected to rapid changes in the environmental characteristics. The monsoonal influence is well noticed in all the parameters studied.

### Salinity

The salinity of perennial field fluctuated much depending on the season (Fig. 44-47). During March and April high salinities (above 20 °/₀₀) prevailed in the field. With the onset of monsoon in May, salinity dropped and with the intensification of monsoon the field was virtually converted to a freshwater body. Fresh water conditions remained till October. From November onwards salinity started to increase slowly but steadily. No salinity stratification was seen during any period.

### Temperature

Monthly distribution of temperature are given in Fig.48-51. As in the case of salinity, the temperature was also influenced by monsoon. Lowest temperature (25.1°C) was noticed in July and highest (34.1°C) in April. The temperature of bottom water was less than that of surface. The temperature of soil was sometimes higher than bottom values and sometimes lower, but never reached surface water values.

Dissolved oxygen

Seasonal variation of dissolved oxygen are shown in Fig.52-55. The water column remained well oxygenated during the time when the system was dominated by fresh water (June-October) Except this period the oxygen values were less. Very low values (less than 2 ml./l) were seen in some stations during certain months. Surface water was better oxygenated than bottom layers.

pH

pH values fluctuated from month to month (Fig. 56-59). Higher values were obtained when the system was saline. The pH decreased with the onset of monsoon. The soil pH ranged from 6.7 - 8.9.

Inorganic phosphates

Distribution pattern of inorganic phosphate are shown in Fig. 60-63. The $PO_4$-P values fluctuated from month to month and year to year. But in both the years highest values were obtained in May and lowest values in August and September. The bottom values were higher in all the stations throughout the period of observation.

Nitrate-Nitrogen

The nitrate-nitrogen distribution is illustrated in Fig.64-67. $NO_3$-N which was found increasing from October attained its peak in January after which the values decreased and reached its minimum in April-May.

With the intensification of S.W. monsoon a second peak was obtained in June-July which again decreased in the subsequent months.

Nitrite-Nitrogen

The peak of nitrite-nitrogen coincided with that of $NO_3$-N (Fig. 68-72). The values were negligible or nil during April, August, September and October. $NO_2$-N values were found decreasing towards the surface.

Ammoniacal nitrogen

The distribution pattern of $NH_4$-N are given in Fig.72-75. Ammonia values were negligible during most of the months. Comparatively higher values were obtained in both the years from December to February.

## DISCUSSION

The environmental characteristics of both the seasonal and perennial fields are influenced by the prevailing meterological conditions of the area. The hydrographic parameters of seasonal fields are not subjected to much fluctuations as in the case of perennial fields. This is because in the seasonal field culture starts in the post-monsoon period and is over by the end of post-monsoon. Hence salinity, which is the most important ecological parameter in these fields shows a steady increase without rapid decrease as seen in the perennial field during monsoon.

season. Same is the case with temperature and pH. But dissolved oxygen were high during October because influence of fresh water. At the time when culture started in the seasonal field, the field was having the stumps of paddy. These start decaying and the low values of oxygen noticed during November-December may be because of the utilisation of oxygen for the biodegration. By December all paddy stumps were seen decayed and hence oxygen need for biodegradation was minimal. This may be the reason for the increase in oxygen from January onwards.

Higher concentration of nutrients seen in the seasonal field from December onwards is because of the regeneration of these as a result of the biodegradation of the plant matter and other organic matter. Thus the parts of the paddy left in the field adds to the fertility of the water column.

The south-west monsoon which started in May had a profound effect on all environmental parameters of the perennial field. The field which was dominated by saline water during pre-monsoon was converted to a fresh water body. This has altered the temperature, pH and dissolved oxygen of the water column. The oxygen values increased in the field because the fresh water conditions prevailing in the field was conducive for more dissolution of oxygen. But the oxygen values never reached saturation levels. Low level of oxygen seen during other periods indicates that the consumption rate of oxygen is more than its replenishment.

The perennial field was nutrient rich because high values of inorganic phosphate (above 2 ug at/l) were obtained throughout the year. Increase in the $PO_4$-P values in May shows that the land run off has some influence in the nutrients of the perennial field. Similarly $NO_3$-N and $NO_2$-N in the field is influenced by the land run off during the monsoon. Sankanarayanan and Quasim (1969) also have reported that the nutrients in the backwater is influenced by land run off.

The environmental parameters of the paddy field also depends on the hydrography of the backwater because the water is supplied to these fields from the backwater. Thus changes in the environmental characteristics in the estuary is reflected in the prawn culture fields also.

Sankanarayanan _et al_. (1982) have reported that the prawn culture fields adjoining the backwater vary in their productivity. The productivity depends ob a number of parameters. The fields under present investigation is situated in densely populated area. The people are using the feeder canals for disposing wastes and other purposes. The adjoining lands are subjected to intense agriculture. The land use pattern and other activities of the people have its influence on the prawn culture fields.

# EXPLANATION TO FIGURES

## ENVIRONMENTAL CHARACTERISTICS OF PRAWN CULTURE FIELDS

### 1. SEASONAL FIELD

| | |
|---|---|
| Fig. 28 & 29 | Distribution of salinity |
| Fig. 30 & 31 | Distribution of temperature |
| Fig. 32 & 33 | Distribution of dissolved oxygen |
| Fig. 34 & 35 | Distribution of pH |
| Fig. 36 & 37 | Distribution of inorganic phosphorus |
| Fig. 38 & 39 | Distribution of Nitrate nitrogen |
| Fig. 40 & 41 | Distribution of Nitrite nitrogen |
| Fig. 42 & 43 | Distribution of Ammoniacal nitrogen. |

### 2. PERENNIAL FIELD

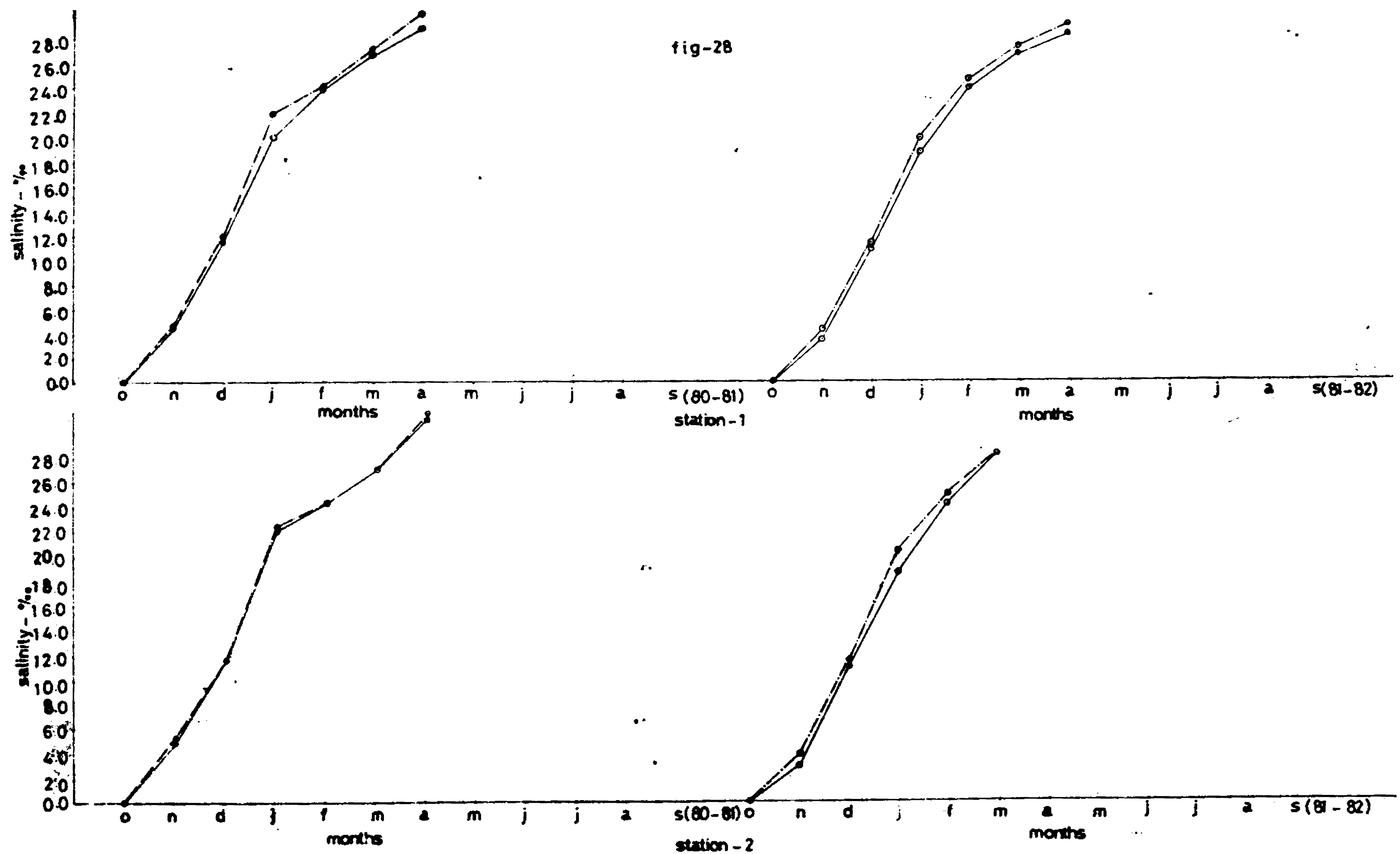
| | |
|---|---|
| Fig. 44 - 47 | Distribution of salinity |
| Fig. 48 - 51 | Distribution of temperature |
| Fig. 52 - 55 | Distribution of dissolved oxygen |
| Fig. 56 - 59 | Distribution of pH |
| Fig. 60 - 63 | Distribution of inorganic phosphorus |
| Fig. 64 - 67 | Distribution of Nitrate nitrogen |
| Fig. 68 - 71 | Distribution of Nitrite nitrogen |
| Fig. 72 - 75 | Distribution of Ammoniacal nitrogen |

——— Surface

-.-.- Bottom

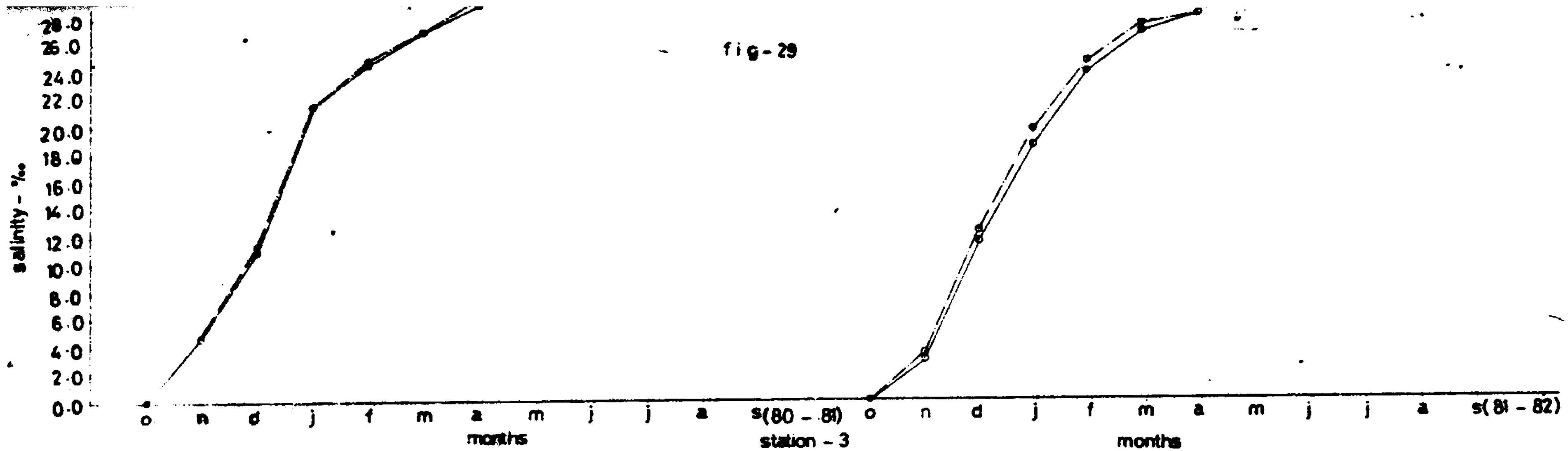
....... Soil

fig-28



salinity - ‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s(81-82)
months
station-1
months
salinity - ‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s(80-81) o n d j f m a m j j a s (81 - 82)
months
station - 2
months

fig-29


salinity - ‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s(80 - 81) o n d j f m a m j j a s(81 - 82)
months
station - 3
months

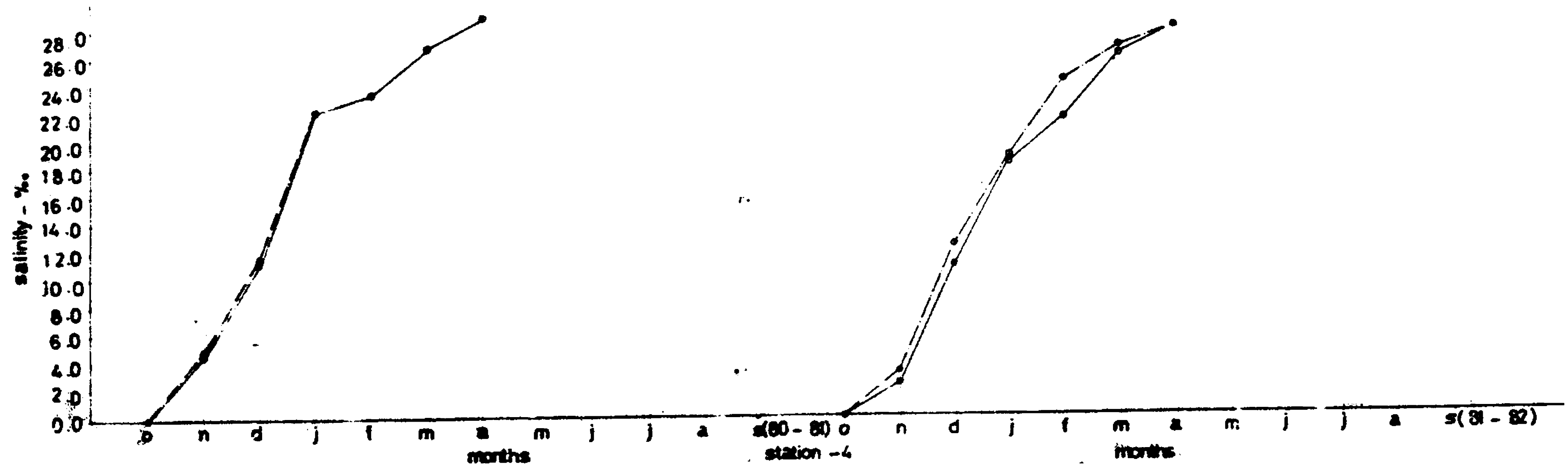
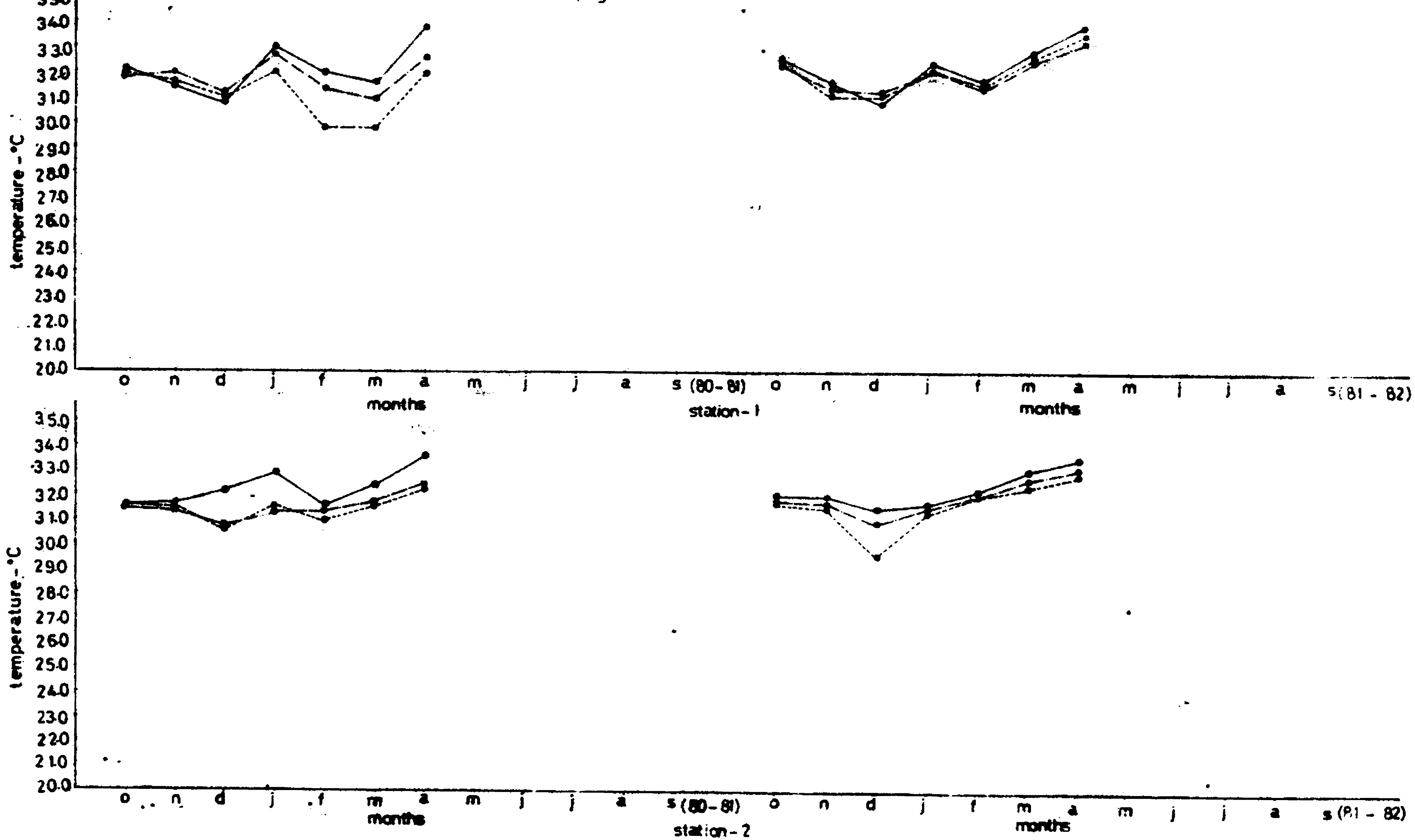

salinity - ‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s(80 - 81) o n d j f m a m j j a s(81 - 82)
months
station - 4
months

fig - 30



temperature - °C
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81 - 82)
months
station - 1
months
temperature - °C
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81 - 82)
months
station - 2
months

fig-31

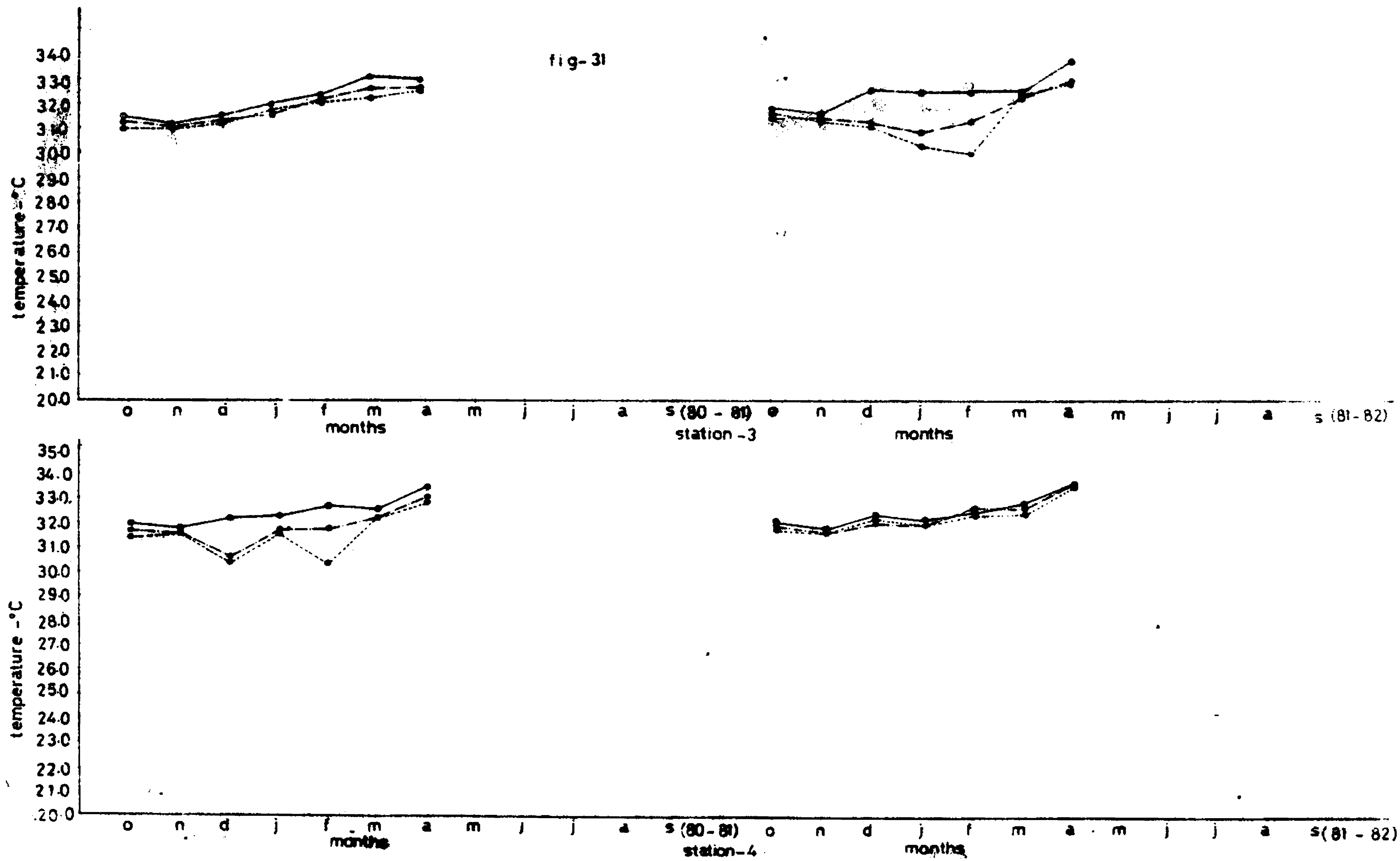
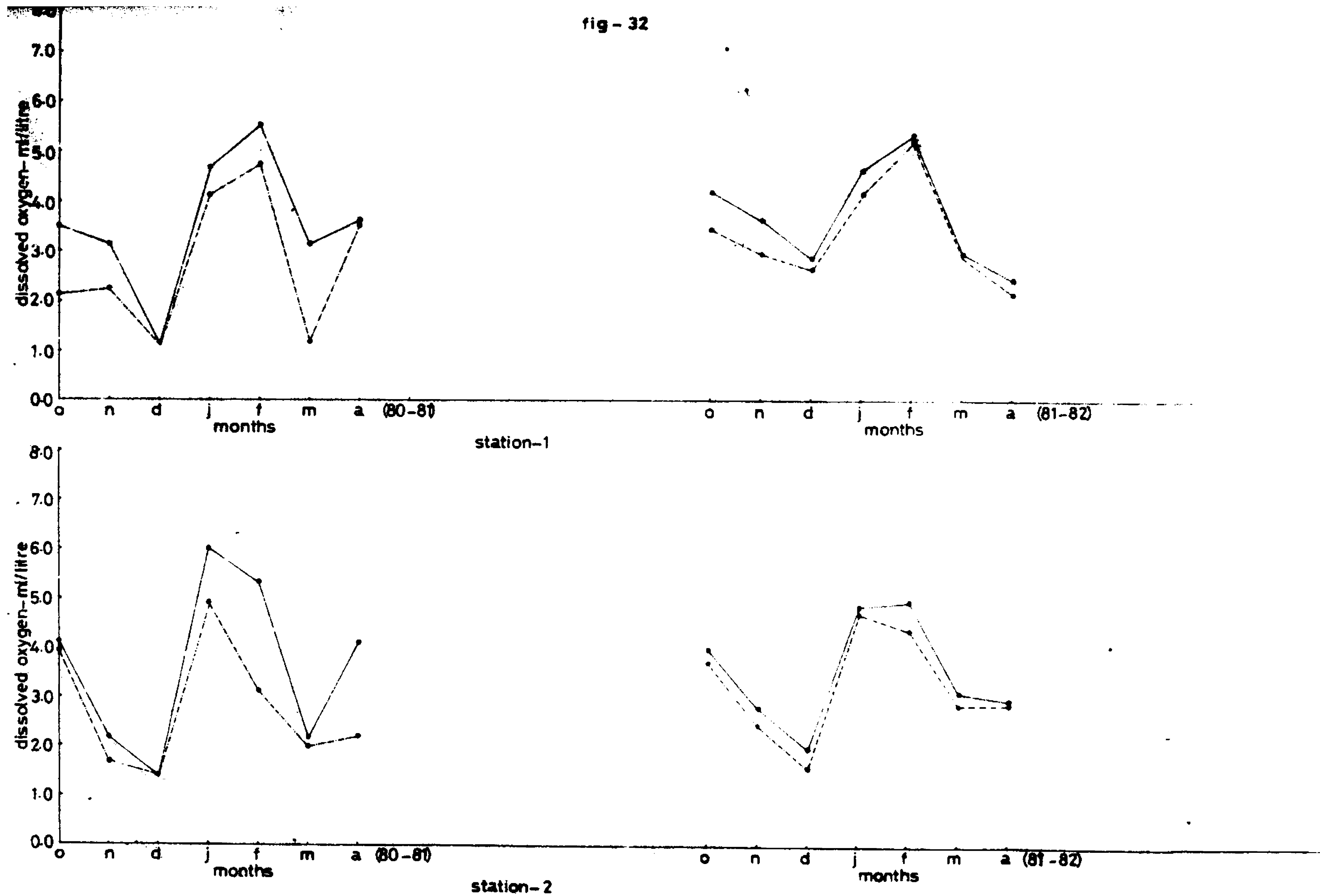

temperature -°C
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
o n d j f m a m j j a s (80 - 81) o n d j f m a m j j a s (81-82)
months
station -3
months
temperature -°C
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s(81 - 82)
months
station-4
months

fig - 32



dissolved oxygen-ml/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a (80-81)
months
o n d j f m a (81-82)
months
station-1
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a (80-81)
months
o n d j f m a (81-82)
months
station-2

fig- 33

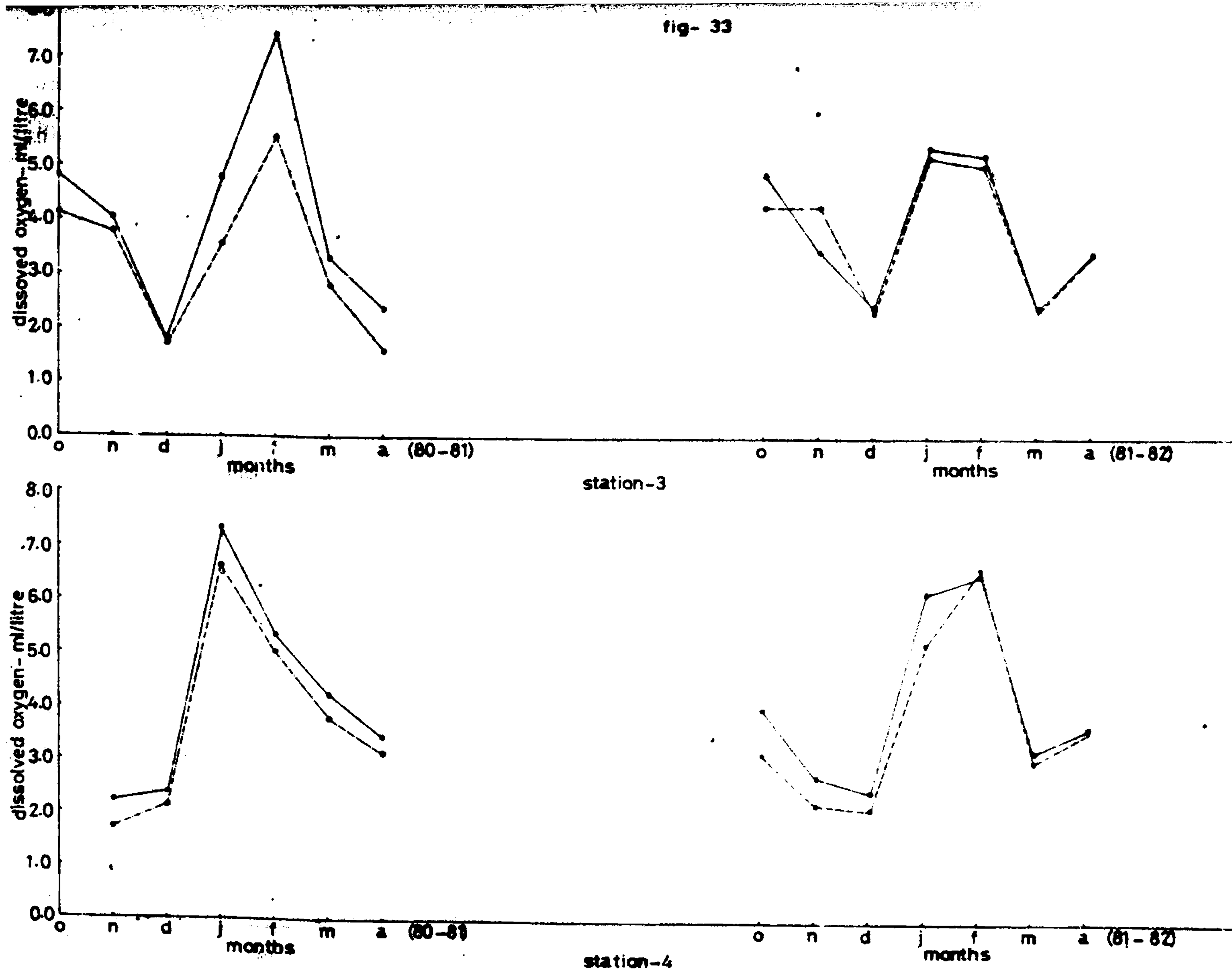
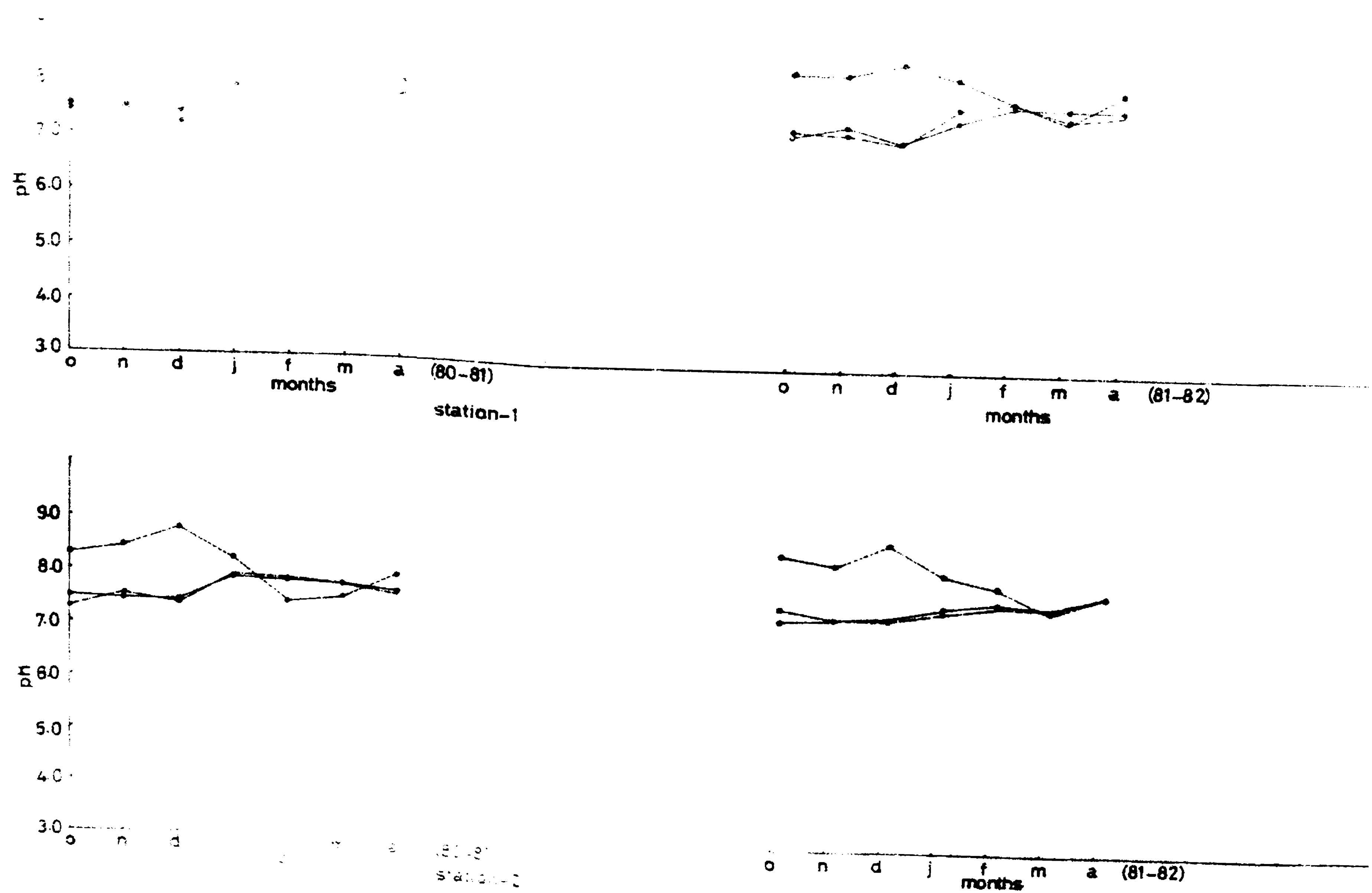
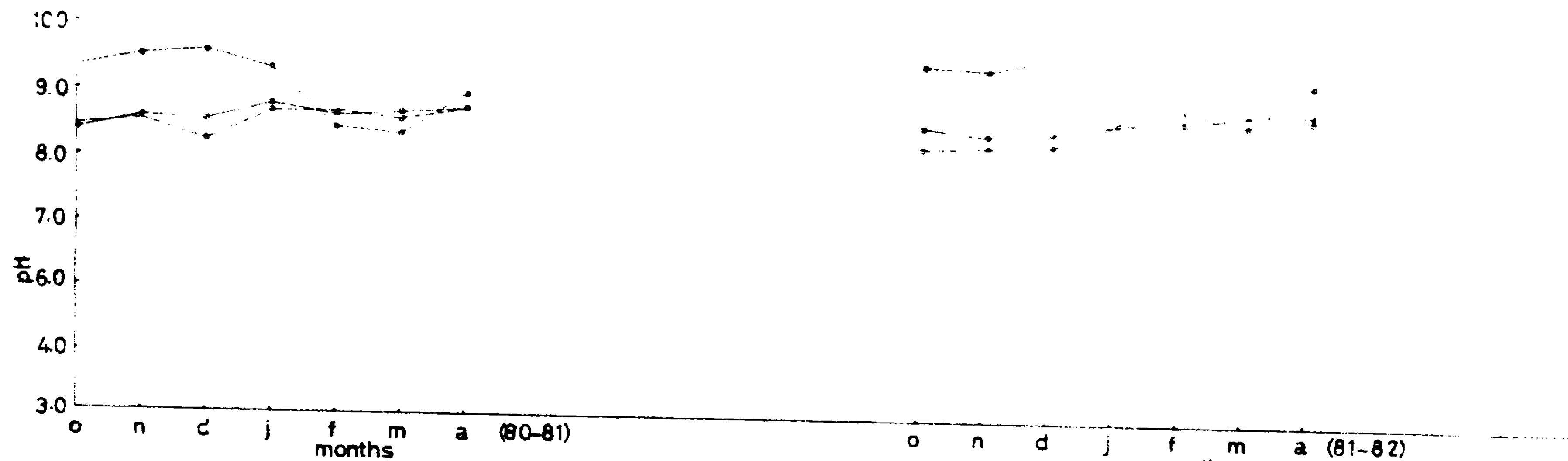

dissolved oxygen- ml/litre
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a (80-81)
months
o n d j f m a (81-82)
months
station-3
dissolved oxygen- ml/litre
o n d j f m a (80-81)
months
o n d j f m a (81-82)
months
station-4

fig- 34

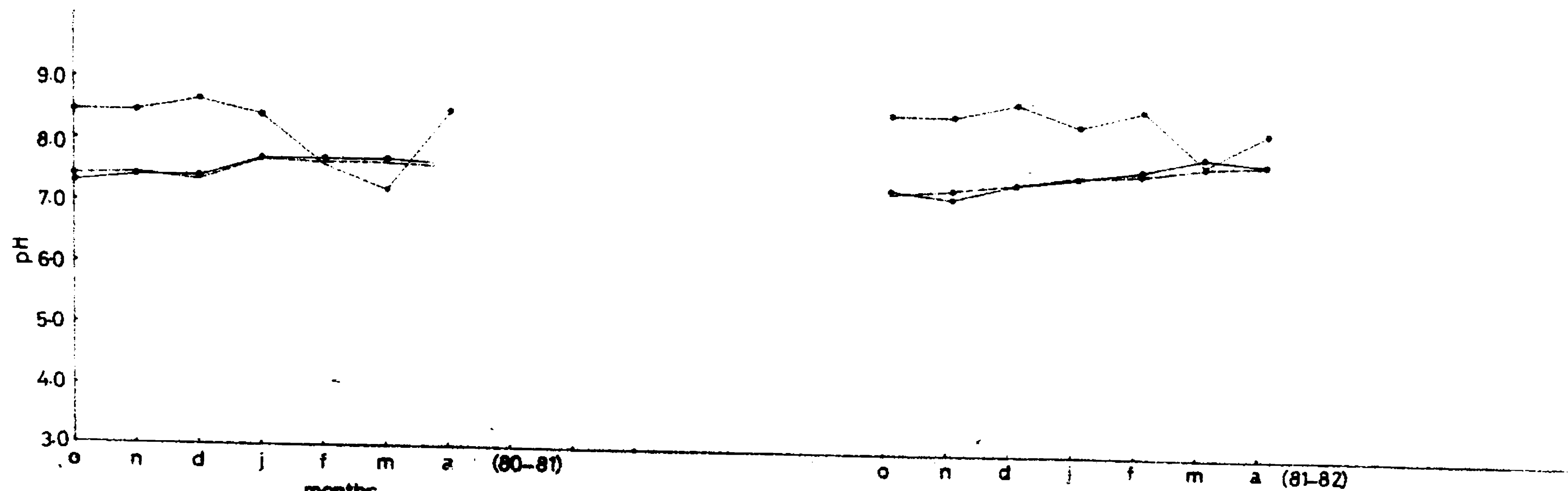


pH
9.0
8.0
7.0
6.0
5.0
4.0
3.0
o
n
d
j
f
m
a
(80-81)
(81-82)
months
station-1
station-2

fig - 35

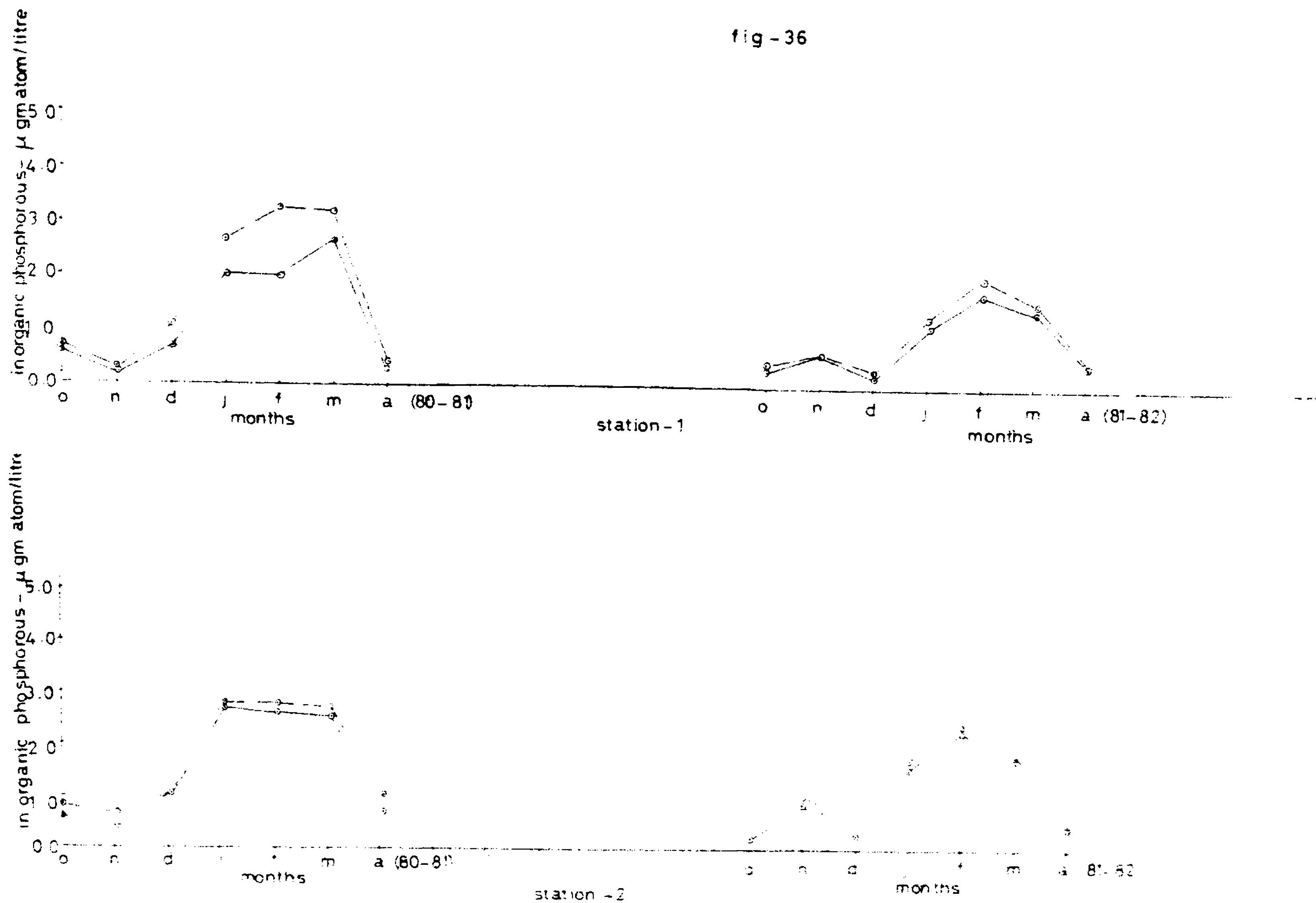



station-3



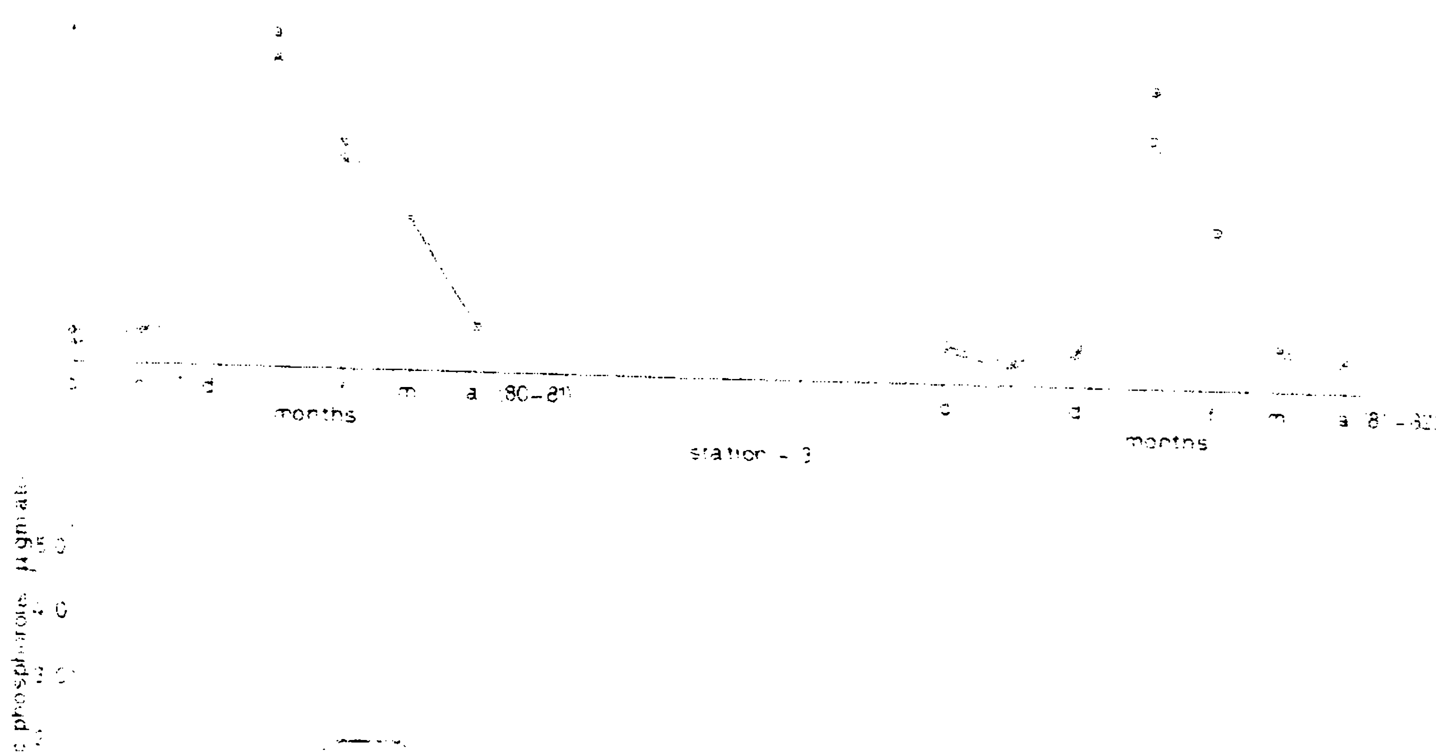

station-4

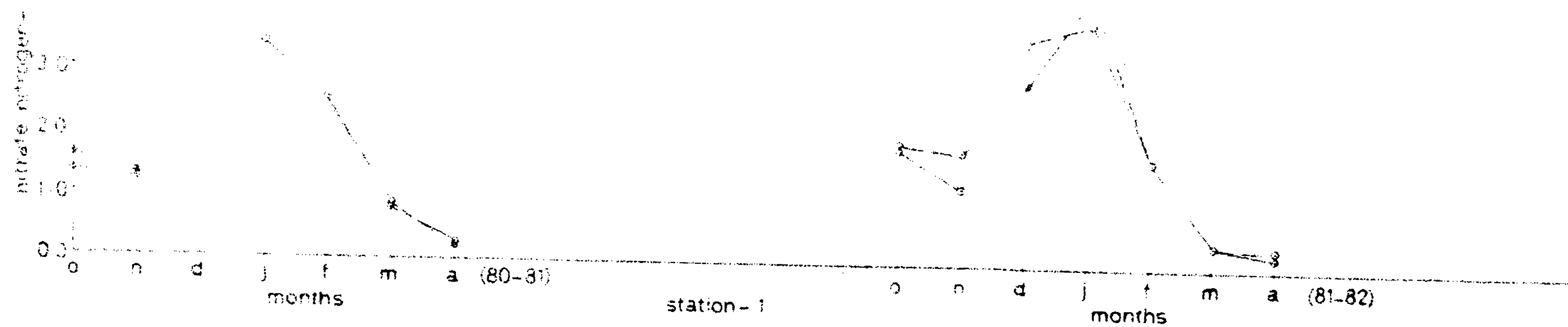
fig - 36



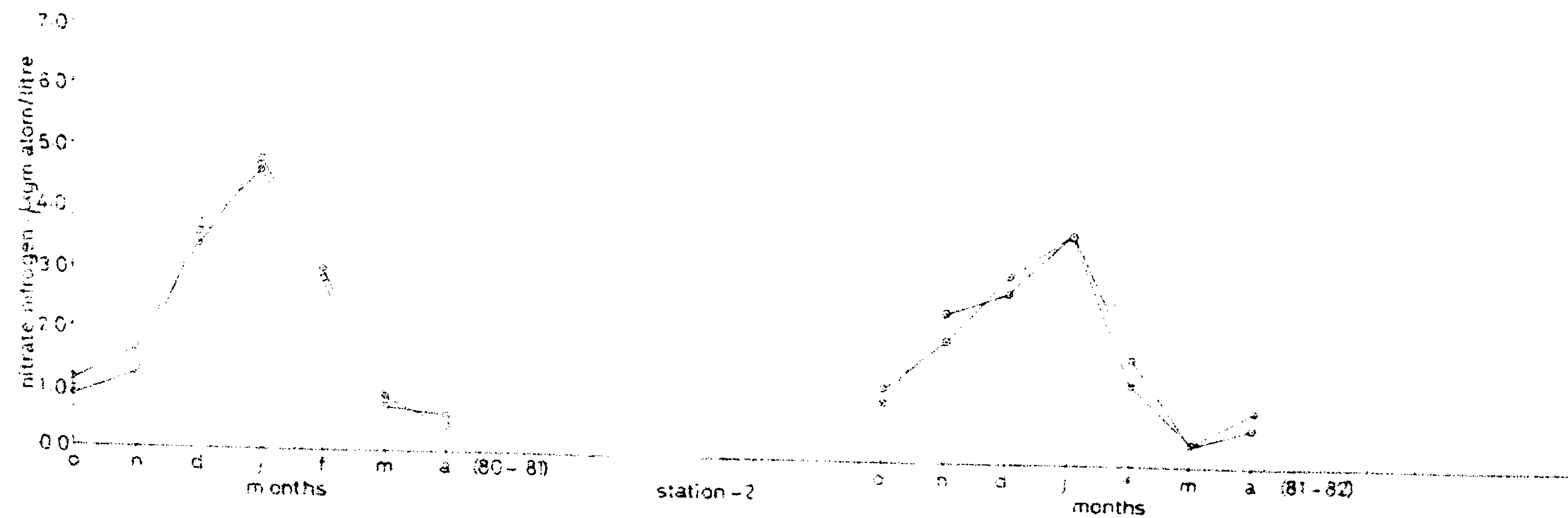
in organic phosphorous - μ gm atom/litre
5.0
4.0
3.0
2.0
1.0
0.0
o
n
d
j
f
m
a (80-81)
months
station - 1
o
n
d
j
f
m
a (81-82)
months
in organic phosphorous - μ gm atom/litre
5.0
4.0
3.0
2.0
1.0
0.0
o
n
d
m
a (80-81)
months
station - 2
o
n
d
m
months

fig -37



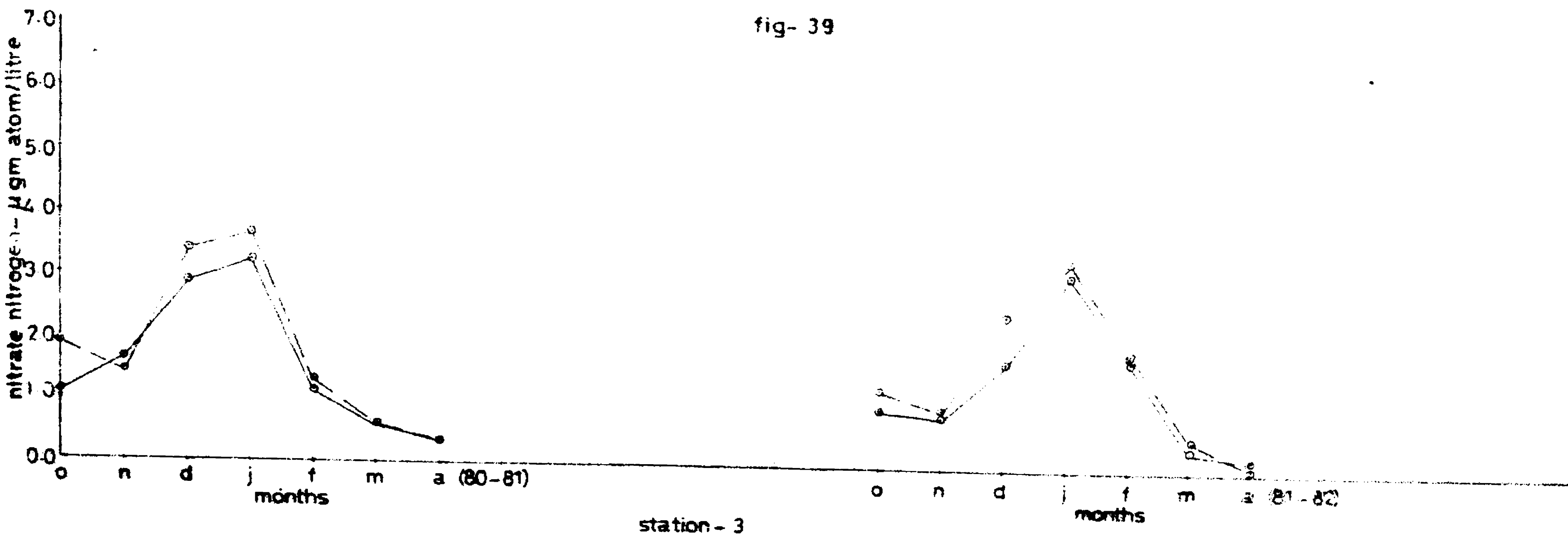


nitrate nitrogen
3.0
2.0
1.0
0.0
o n d j f m a (80–81)
months
station – 1
o n d j f m a (81–82)
months

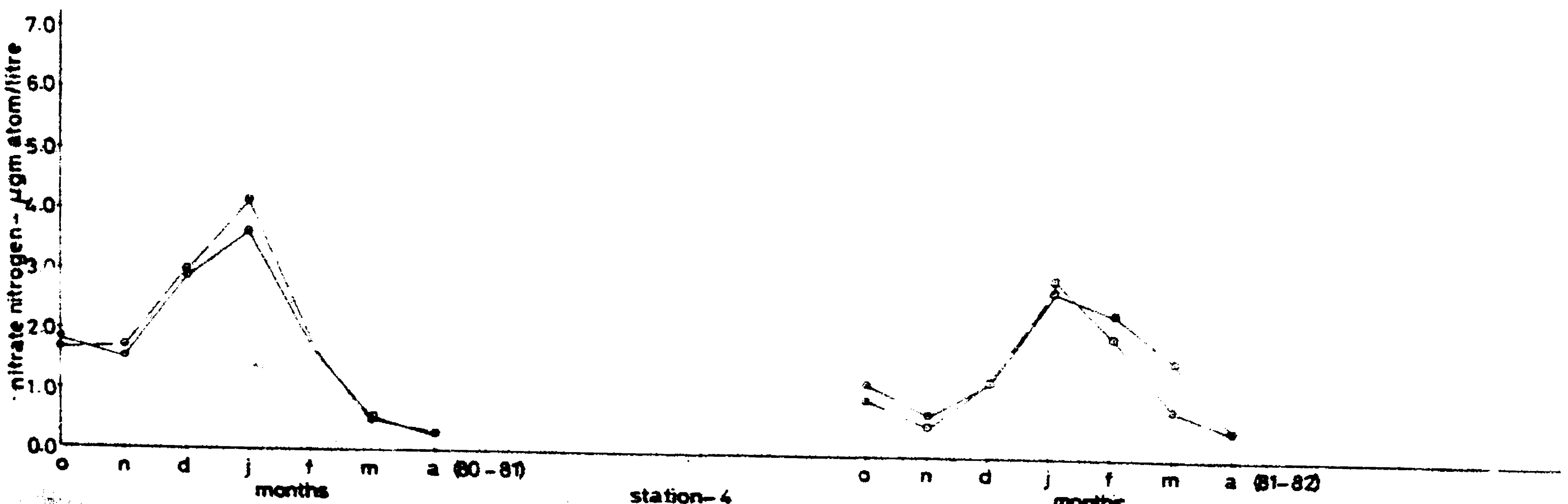



nitrate nitrogen µgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a (80 – 81)
months
station – 2
o n d j f m a (81 – 82)
months

fig- 39

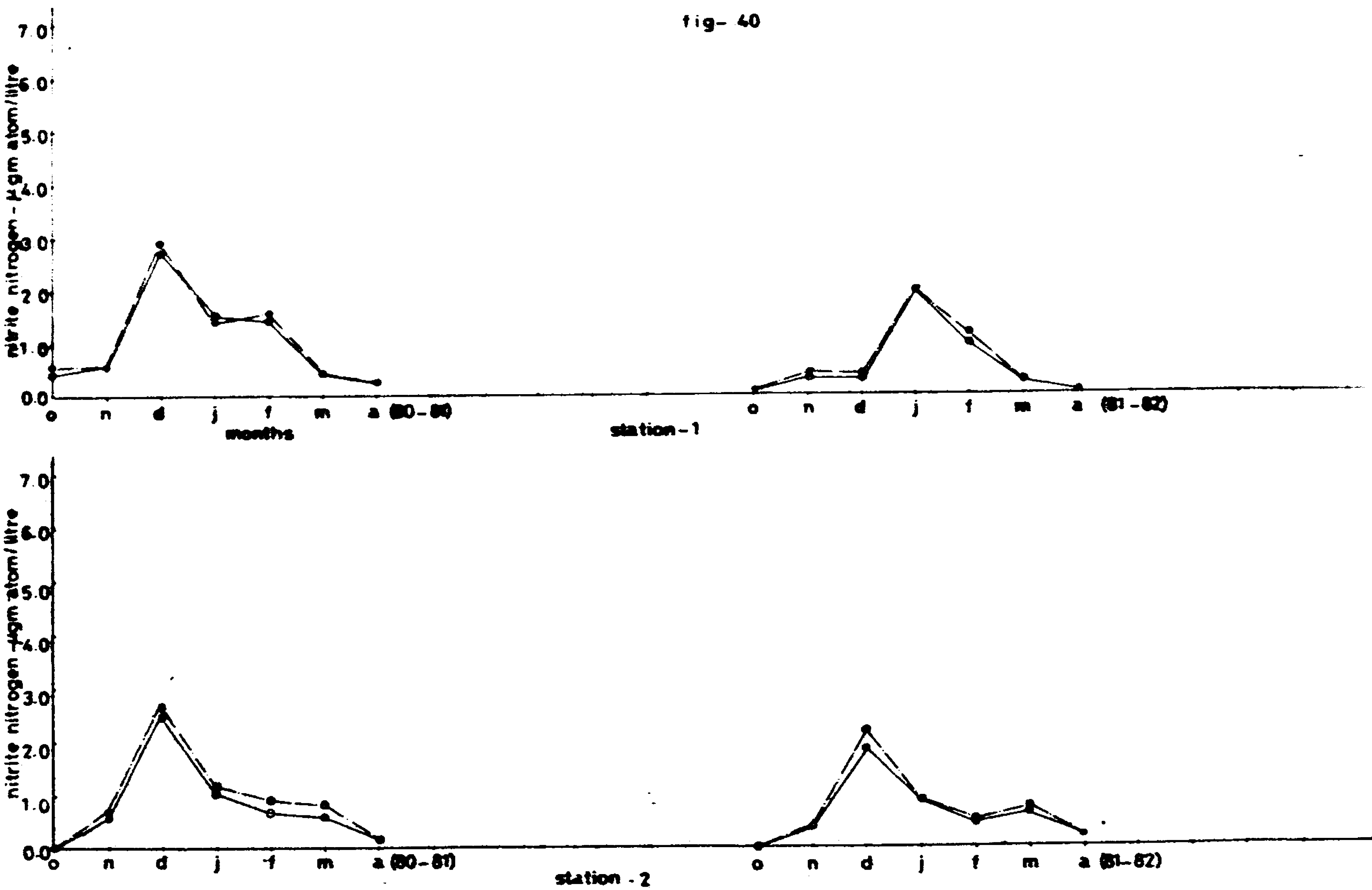



station - 3

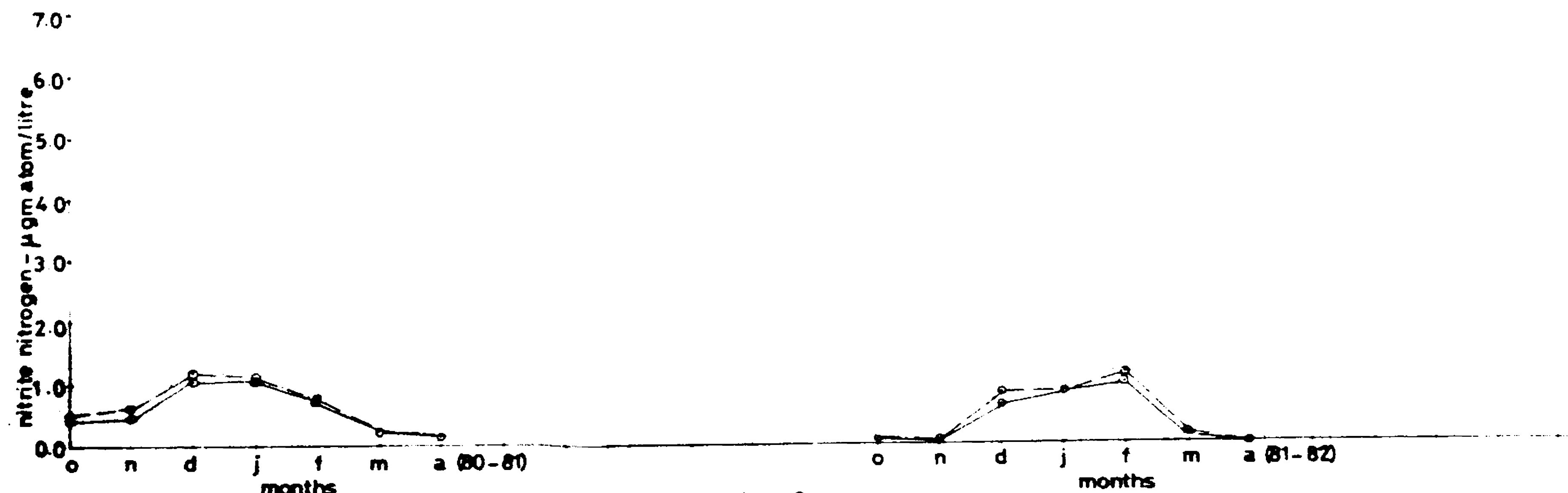



station- 4

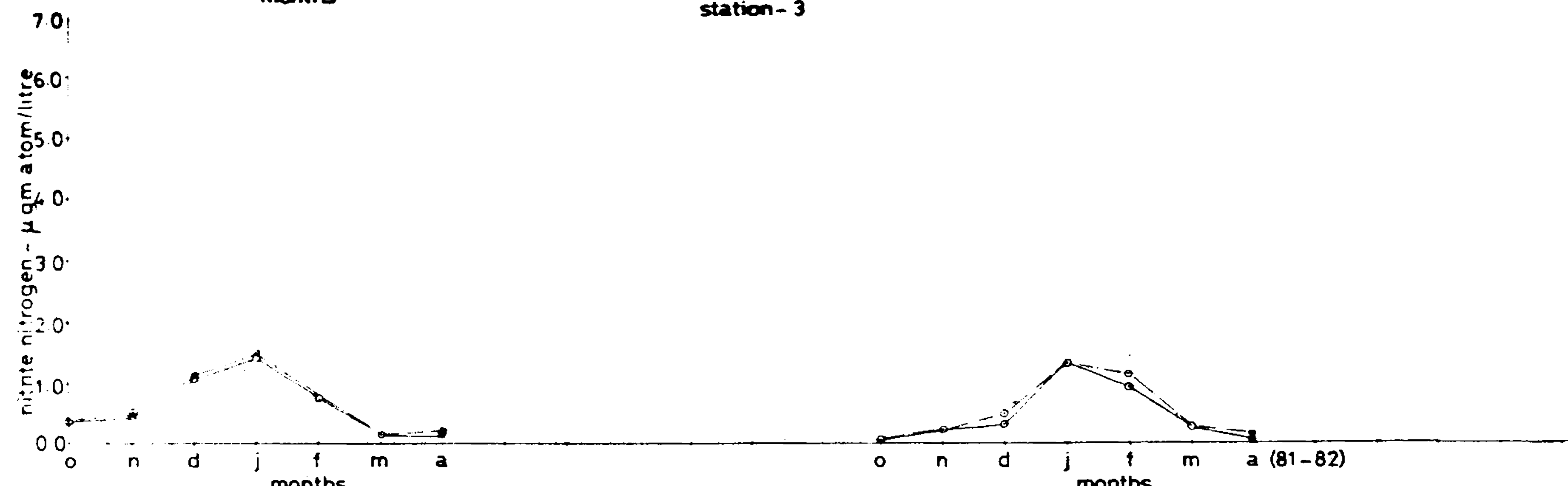
fig- 40



nitrite nitrogen - µgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a (80-81)
months
station-1
o n d j f m a (81-82)
nitrite nitrogen -µgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a (80-81)
station - 2
o n d j f m a (81-82)

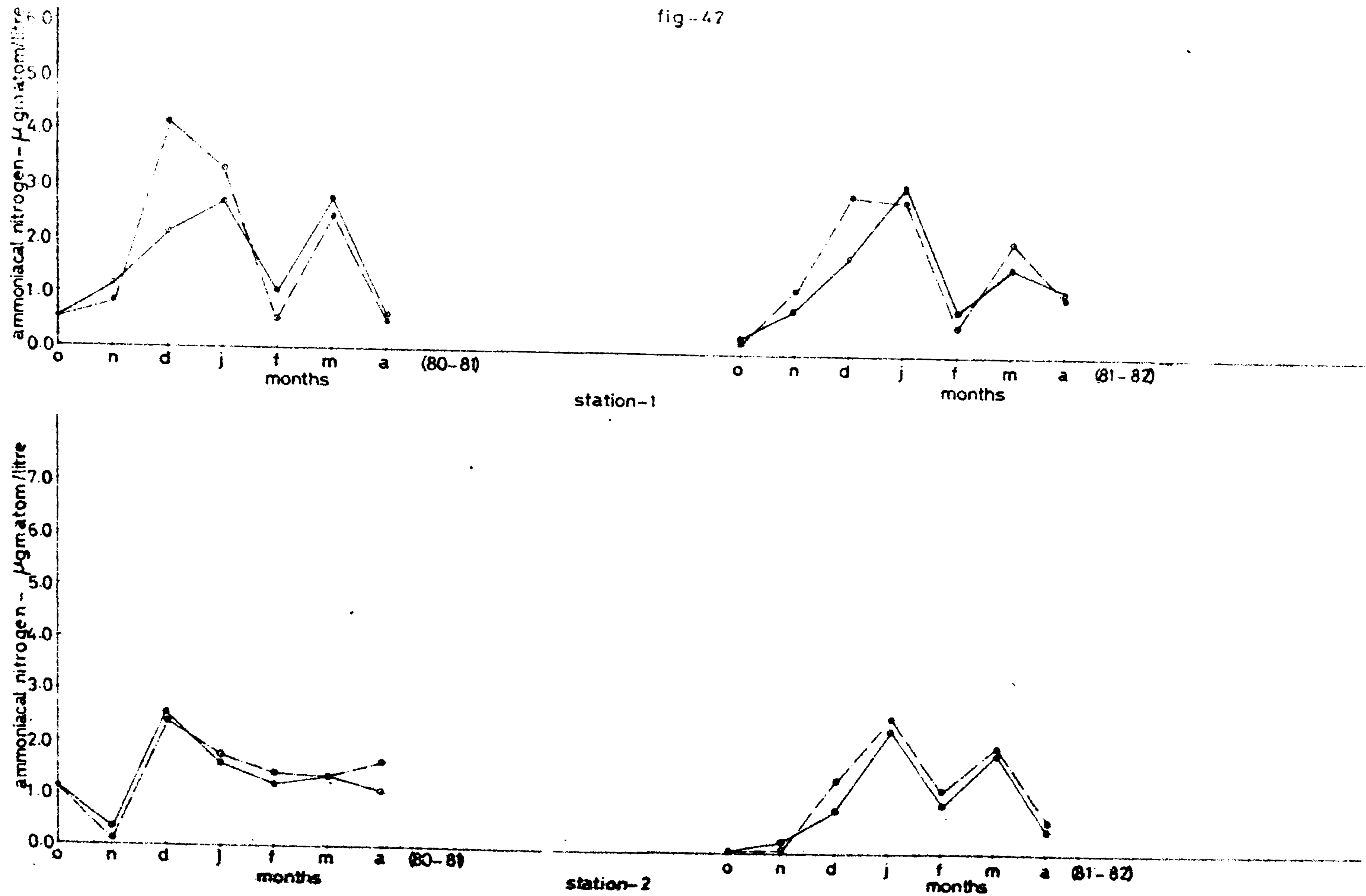


station - 3



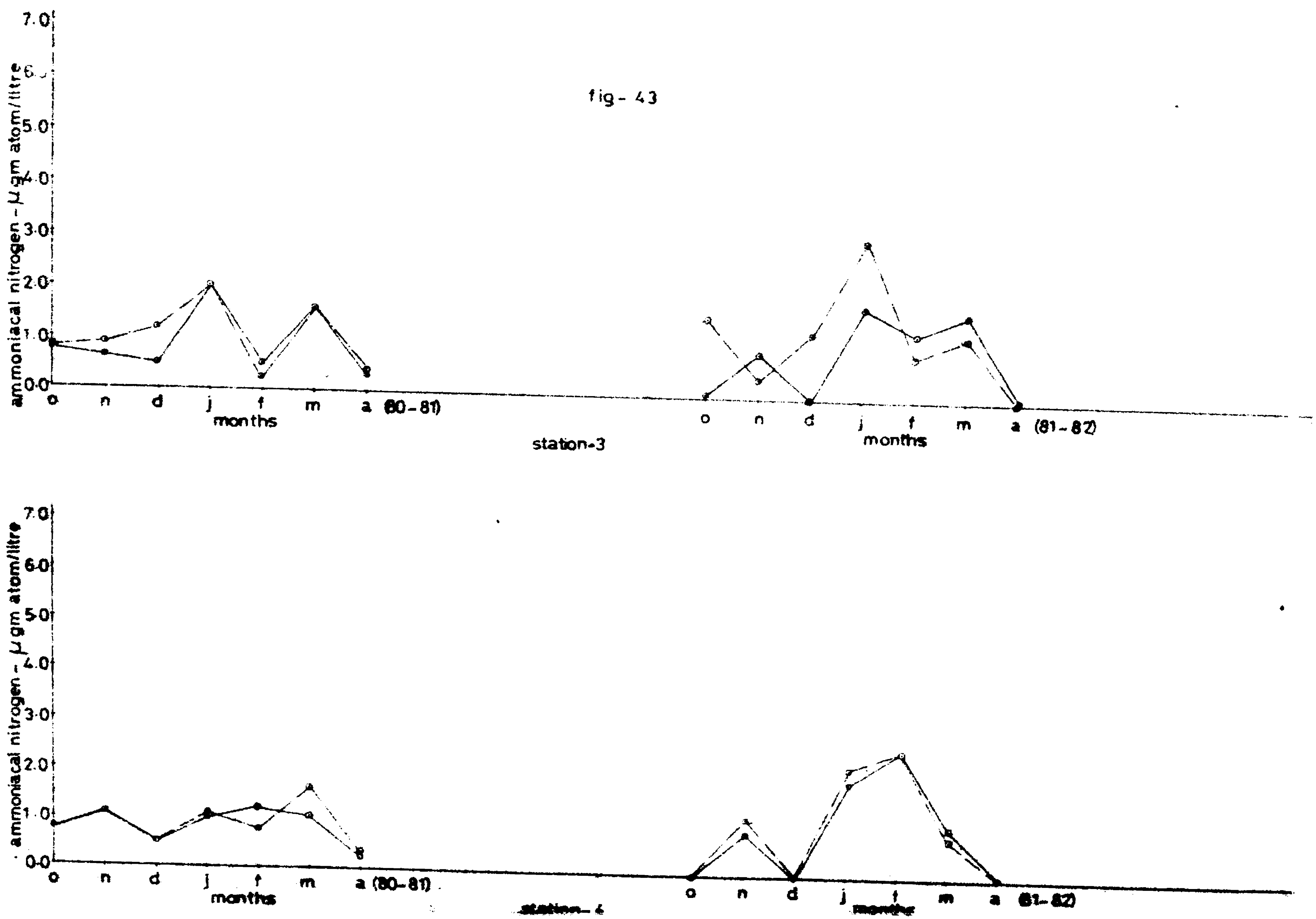
station - 4

fig-47



ammoniacal nitrogen - μg m atom/litre
0.0
1.0
2.0
3.0
4.0
5.0
6.0
o n d j f m a (80-81)
months
o n d j f m a (81-82)
months
station-1
ammoniacal nitrogen - μgmatom/litre
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
o n d j f m a (80-81)
months
o n d j f m a (81-82)
months
station-2

fig- 43



ammoniacal nitrogen - µgm atom/litre
7.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a (80-81)
months
o n d j f m a (81-82)
months
station-3
ammoniacal nitrogen - µgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a (80-81)
months
o n d j f m a (81-82)

fig - 44

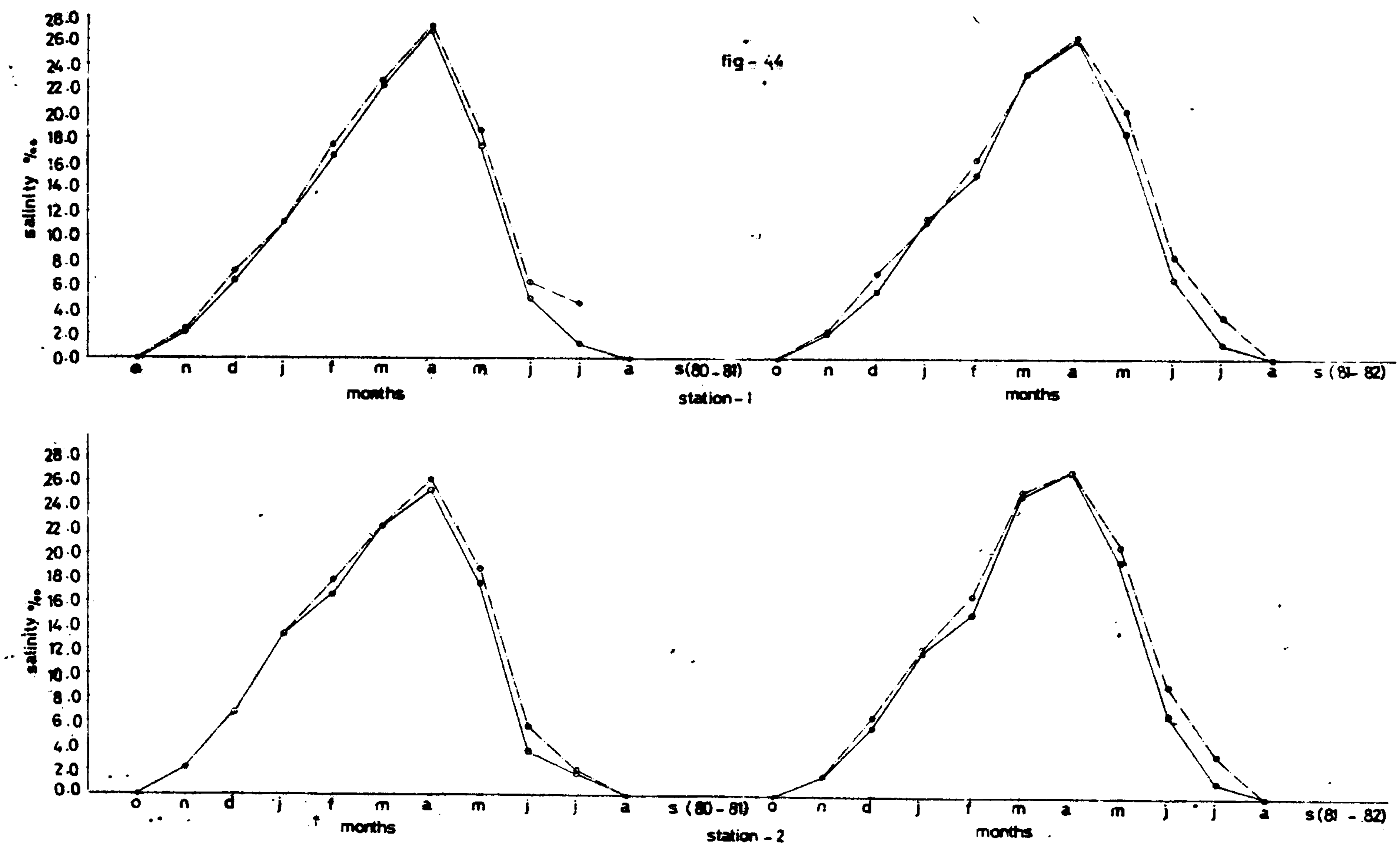
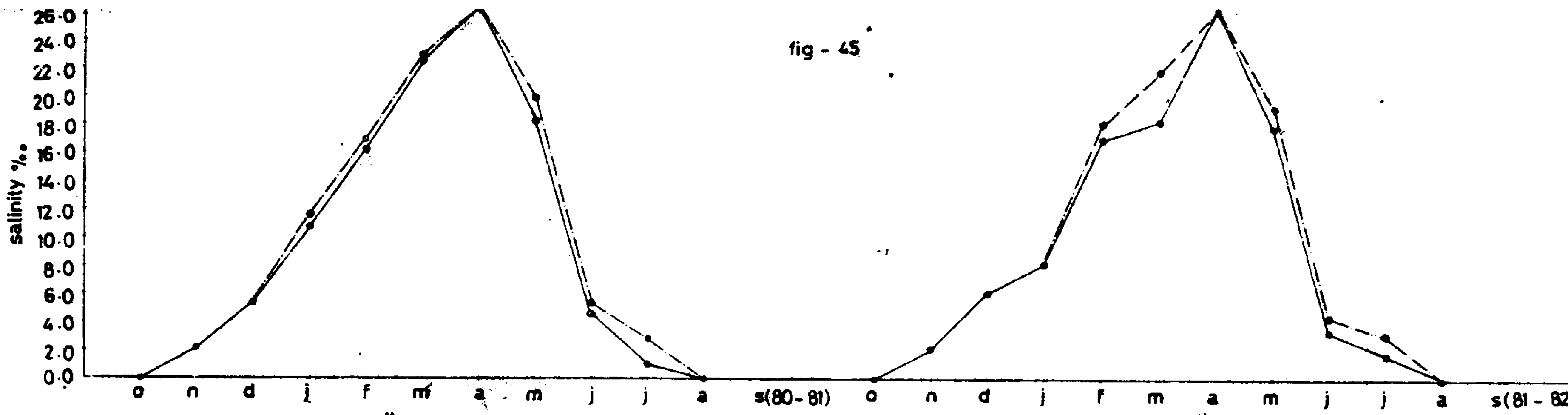
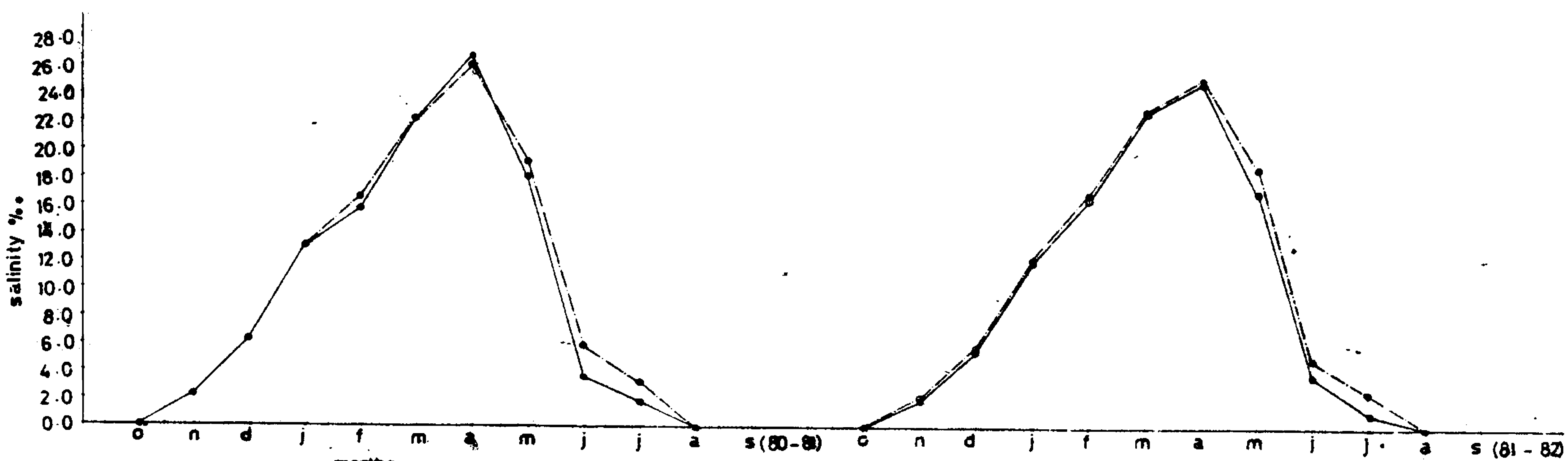

salinity ‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s(80-81) o n d j f m a m j j a s(81-82)
months
station - 1
months
salinity ‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s(81 - 82)
months
station - 2
months

fig - 45




station - 3




station - 4

fig - 46

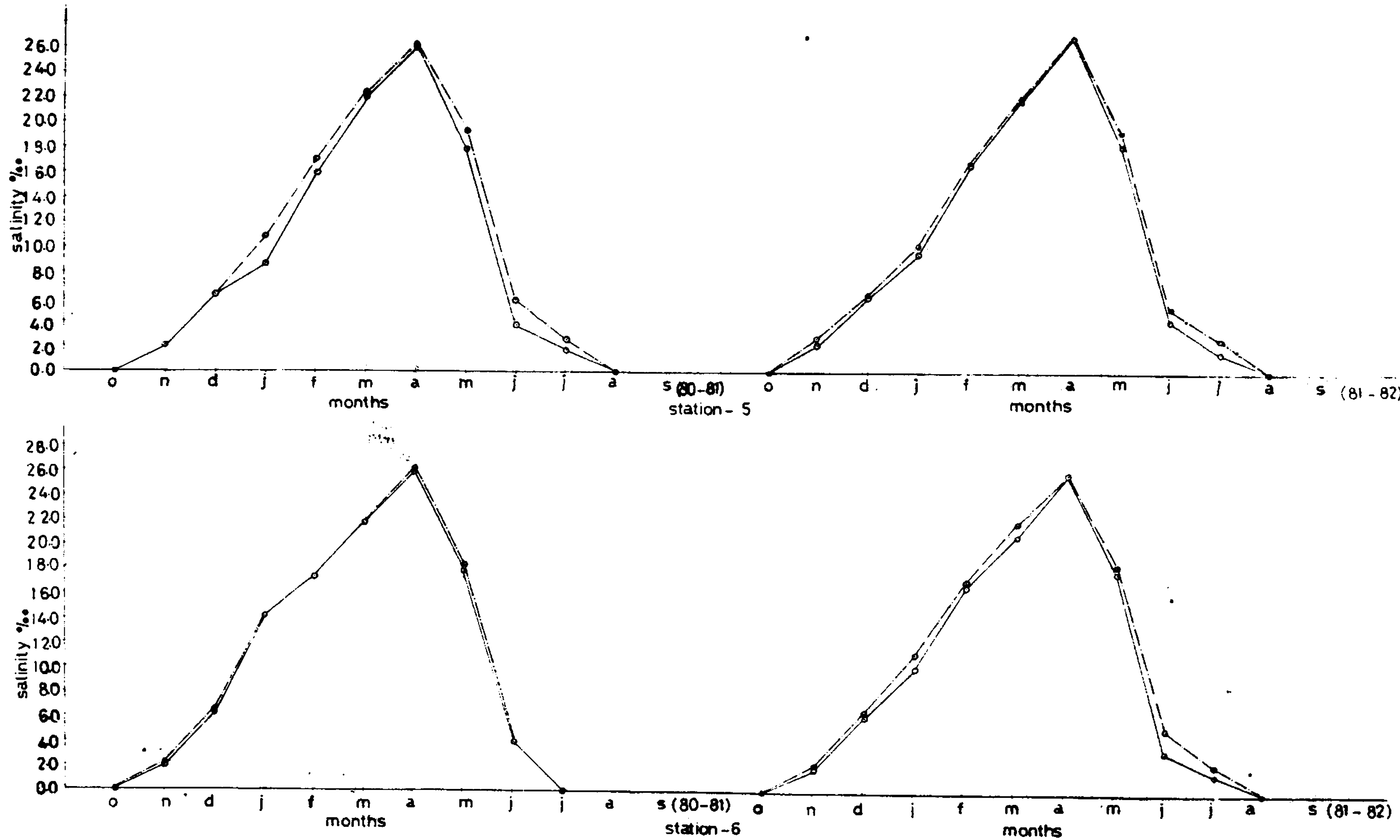

salinity ‰
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station - 5
months
salinity ‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station - 6
months

fig.-47

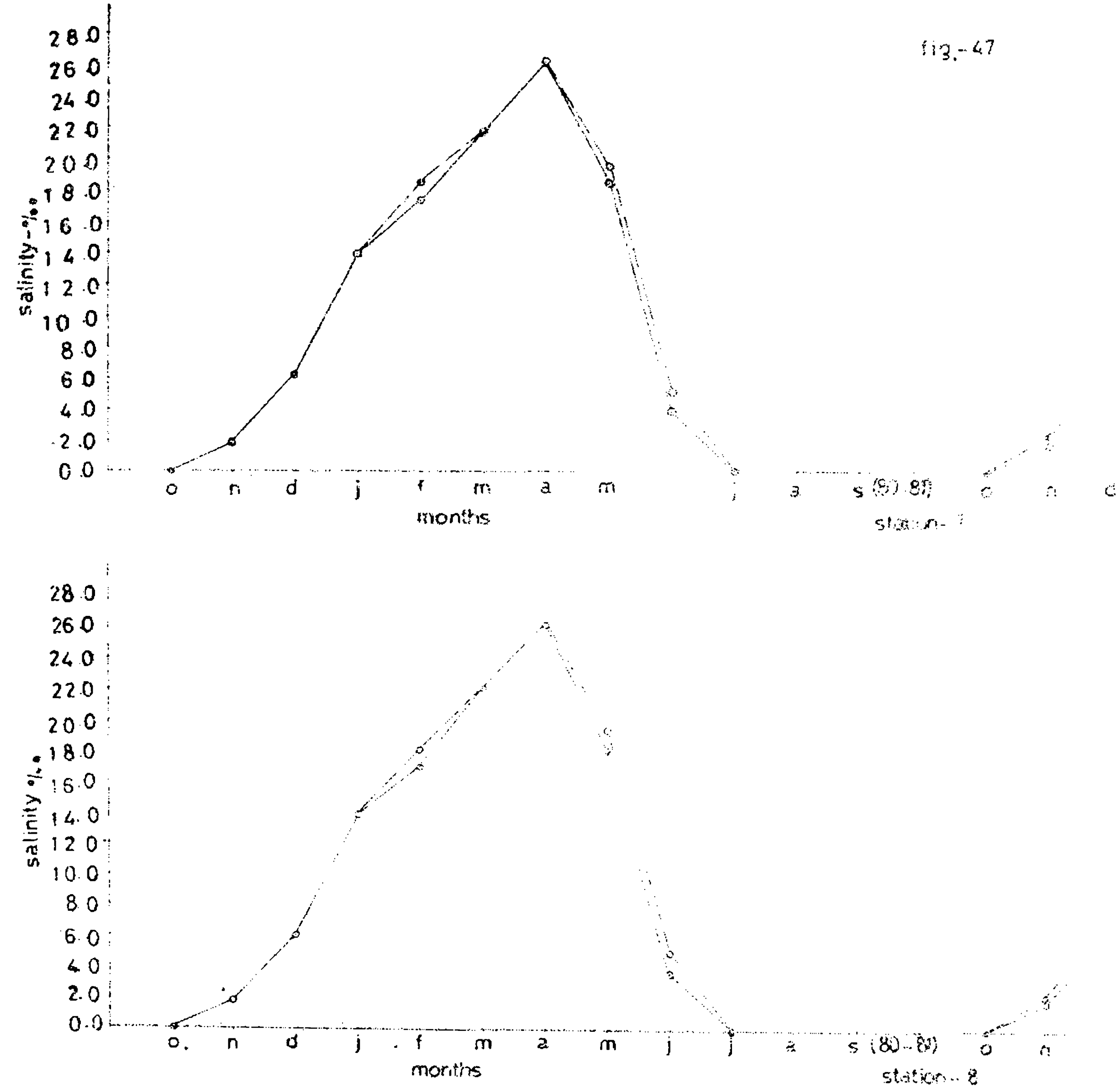

salinity-‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j a s (80-81) o n d
months
station-7
salinity ‰
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s (80-81) o n
months
station-8

fig-48

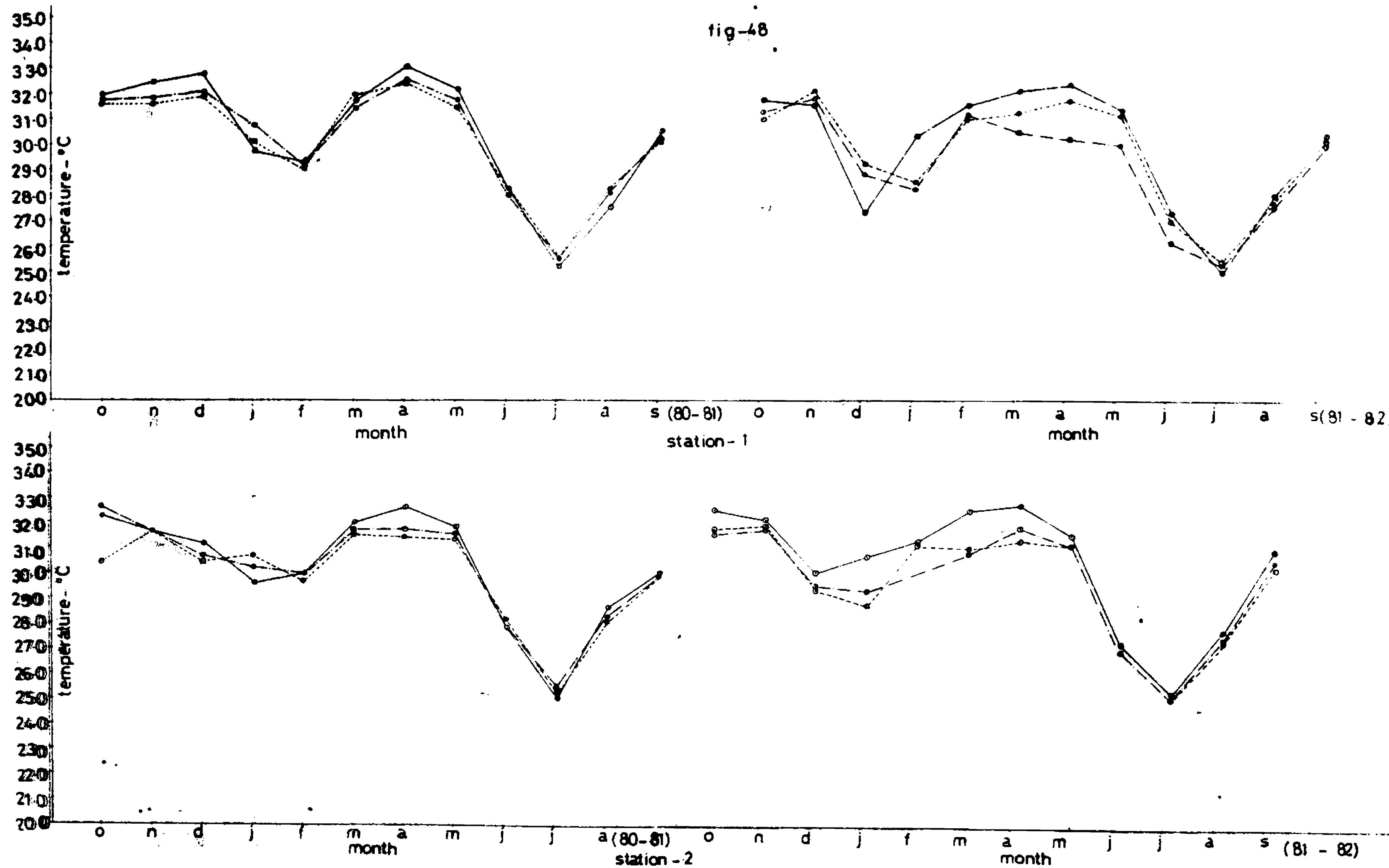

35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
temperature - °C
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s(81 - 82)
month
station - 1
month
temperature - °C
o n d j f m a m j j a(80-81) o n d j f m a m j j a s (81 - 82)
month
station - 2
month

fig-49

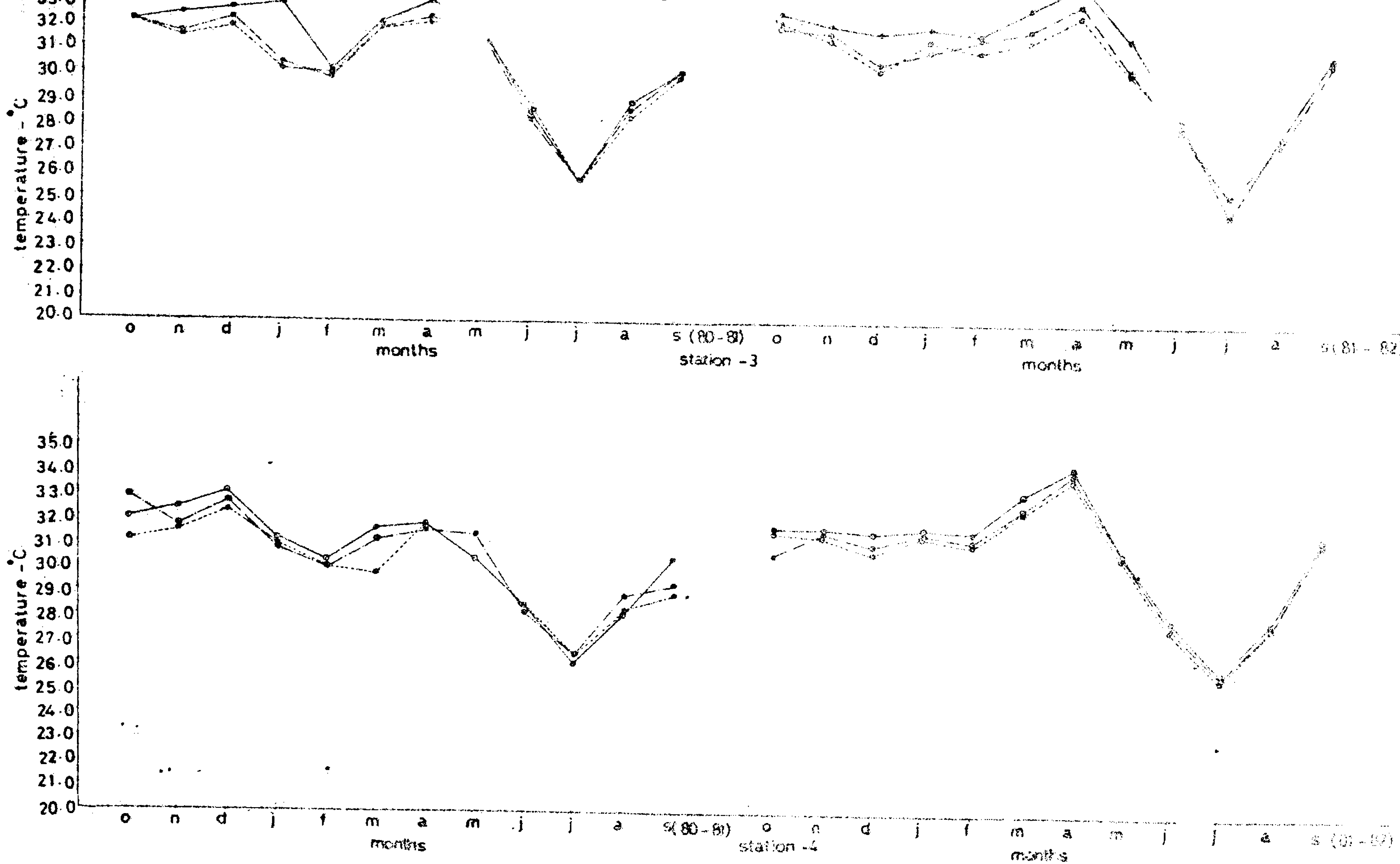

temperature - °C
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station -3
months
temperature - °C
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station -4
months

fig - 50

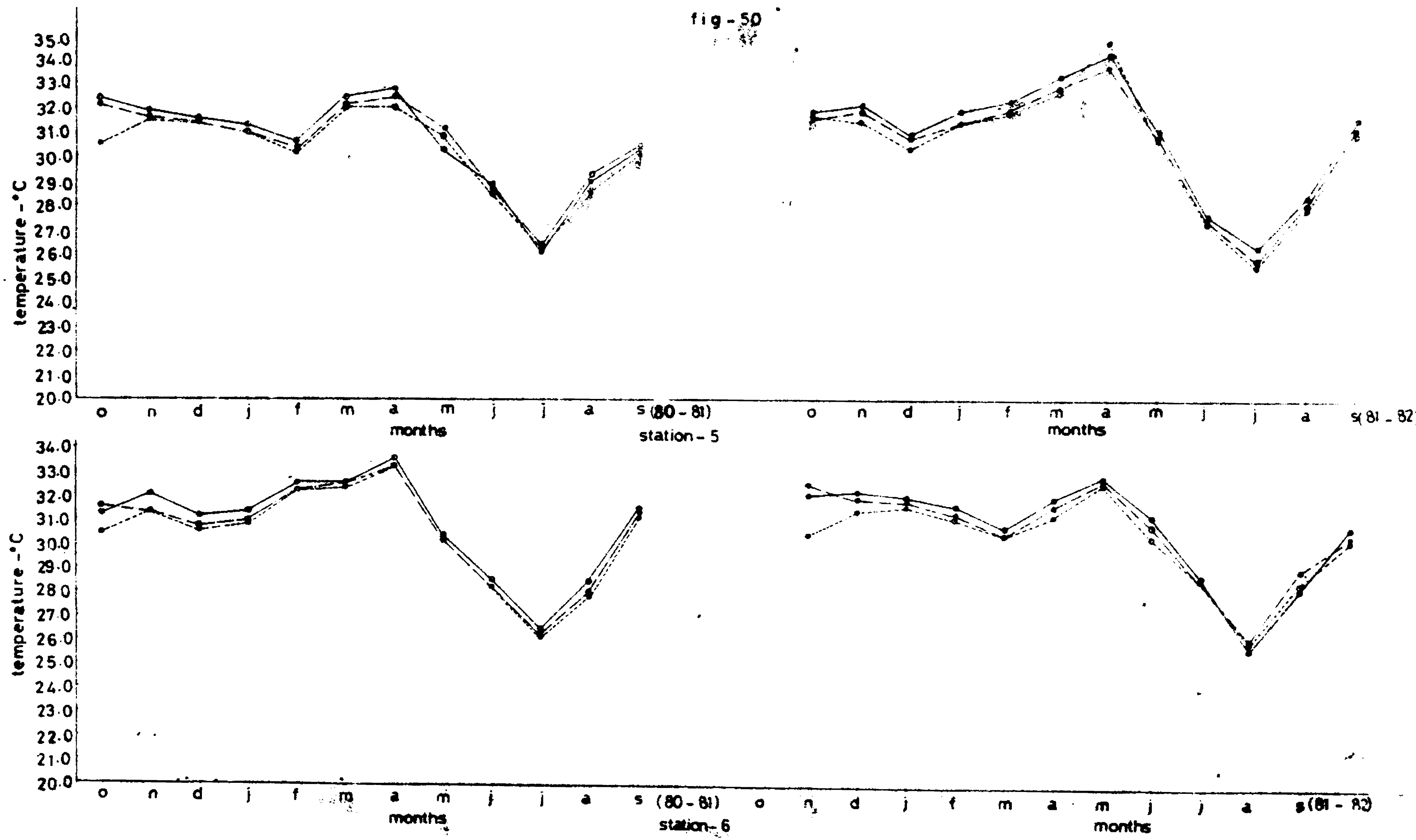
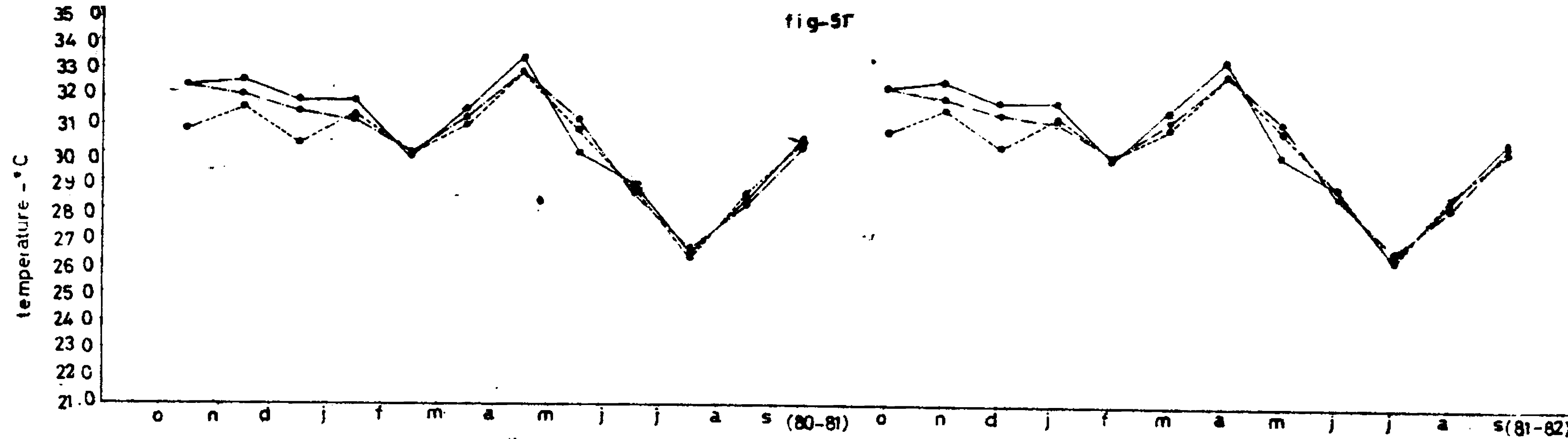
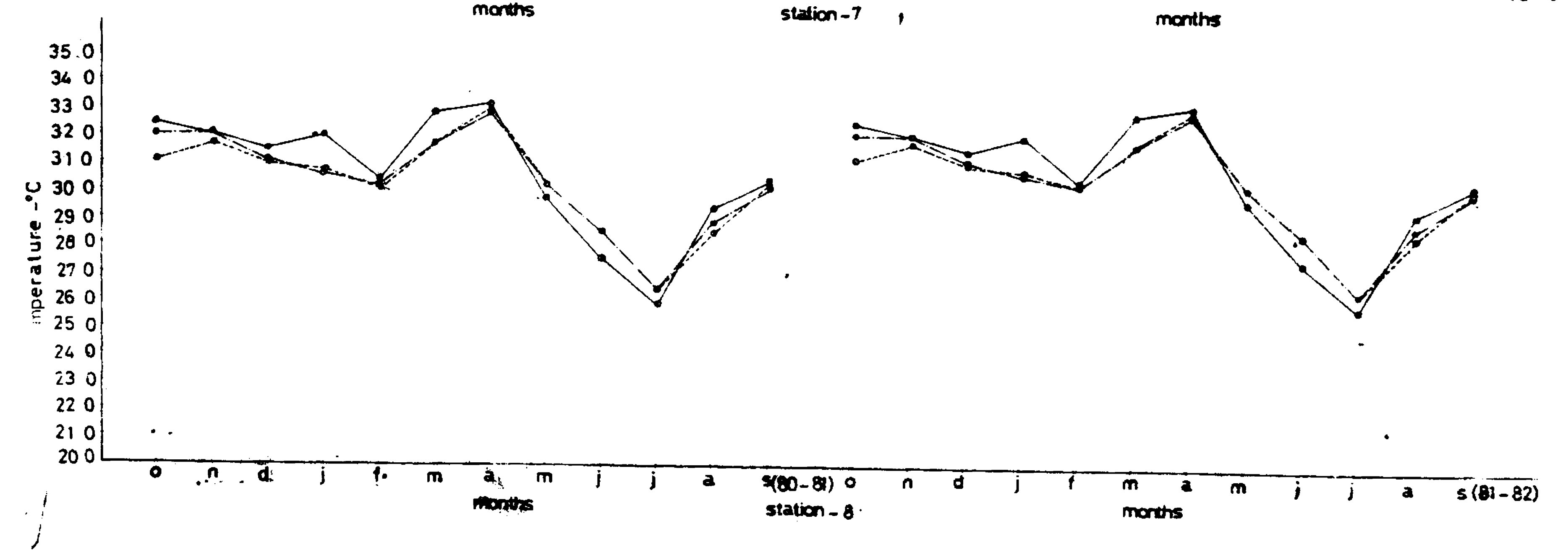

temperature - °C
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
o n d j f m a m j j a s (80 - 81)
months
station - 5
o n d j f m a m j j a s (81 - 82)
months
temperature - °C
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
o n d j f m a m j j a s (80 - 81)
months
station - 6
o n d j f m a m j j a s (81 - 82)
months

fig-5T




station - 7




station - 8

fig - 52

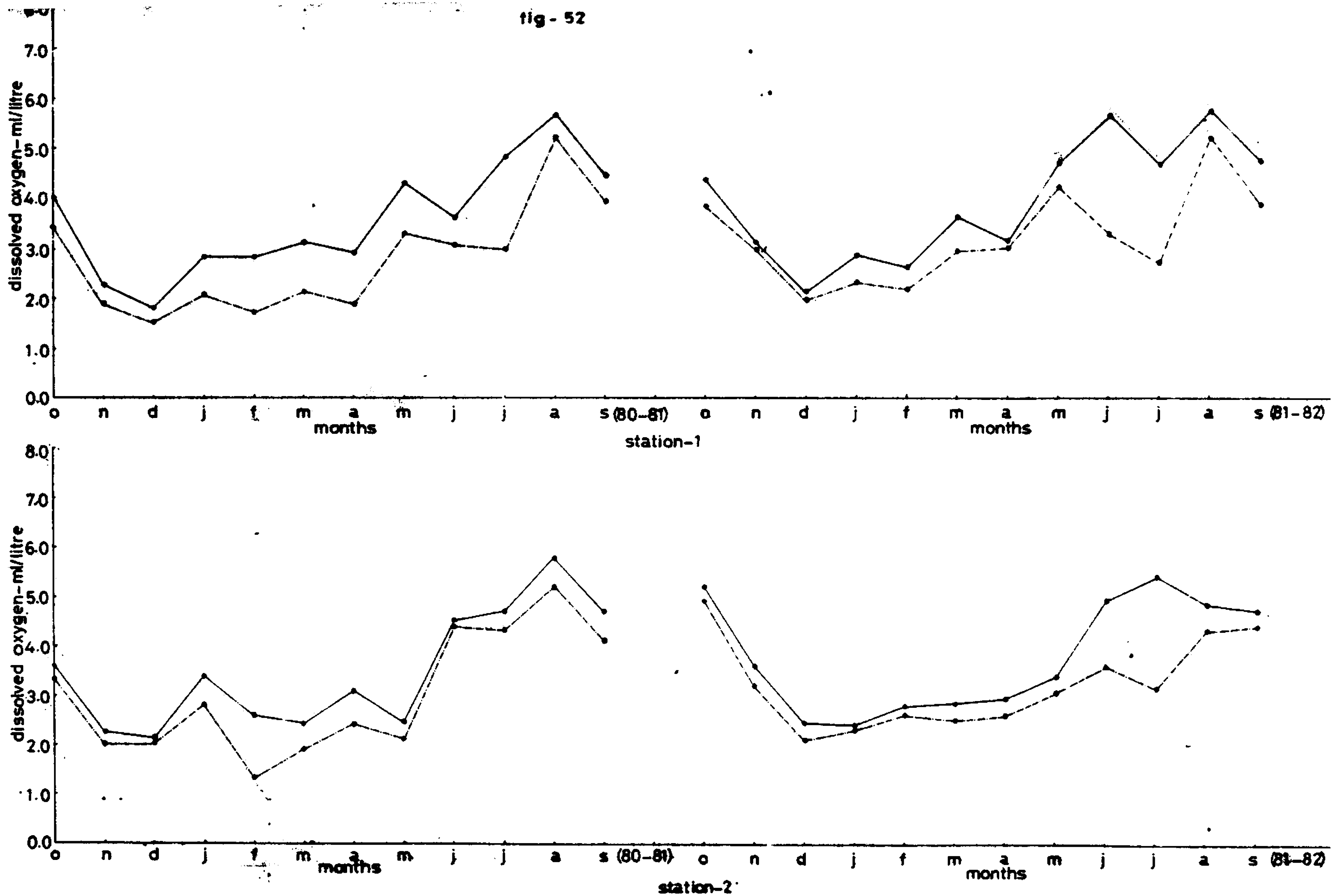
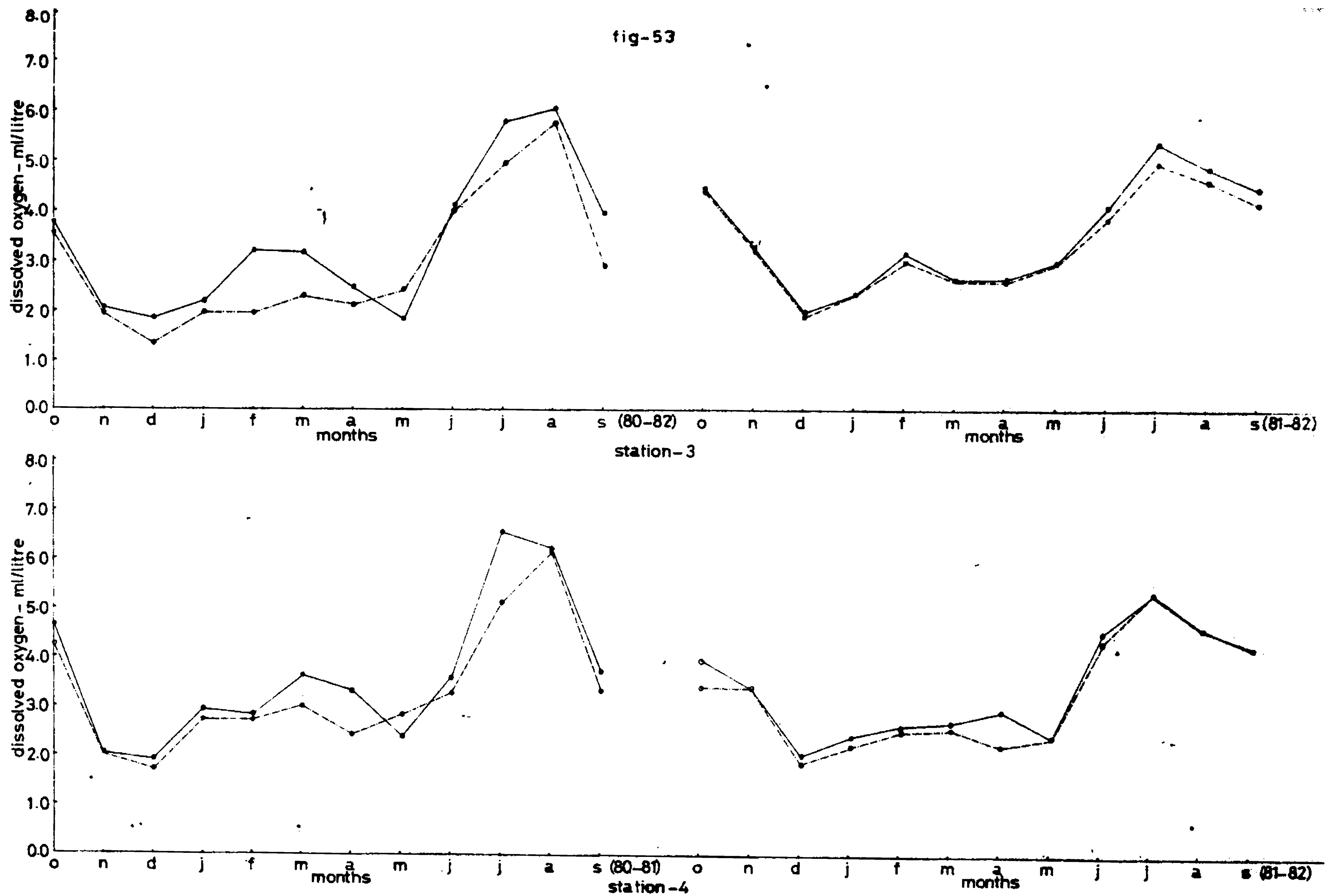

dissolved oxygen-ml/litre
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station-1
station-2

fig-53



dissolved oxygen - ml/litre
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a m j j a s (80-82) o n d j f m a m j j a s(81-82)
months
months
station-3
dissolved oxygen - ml/litre
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
months
station-4

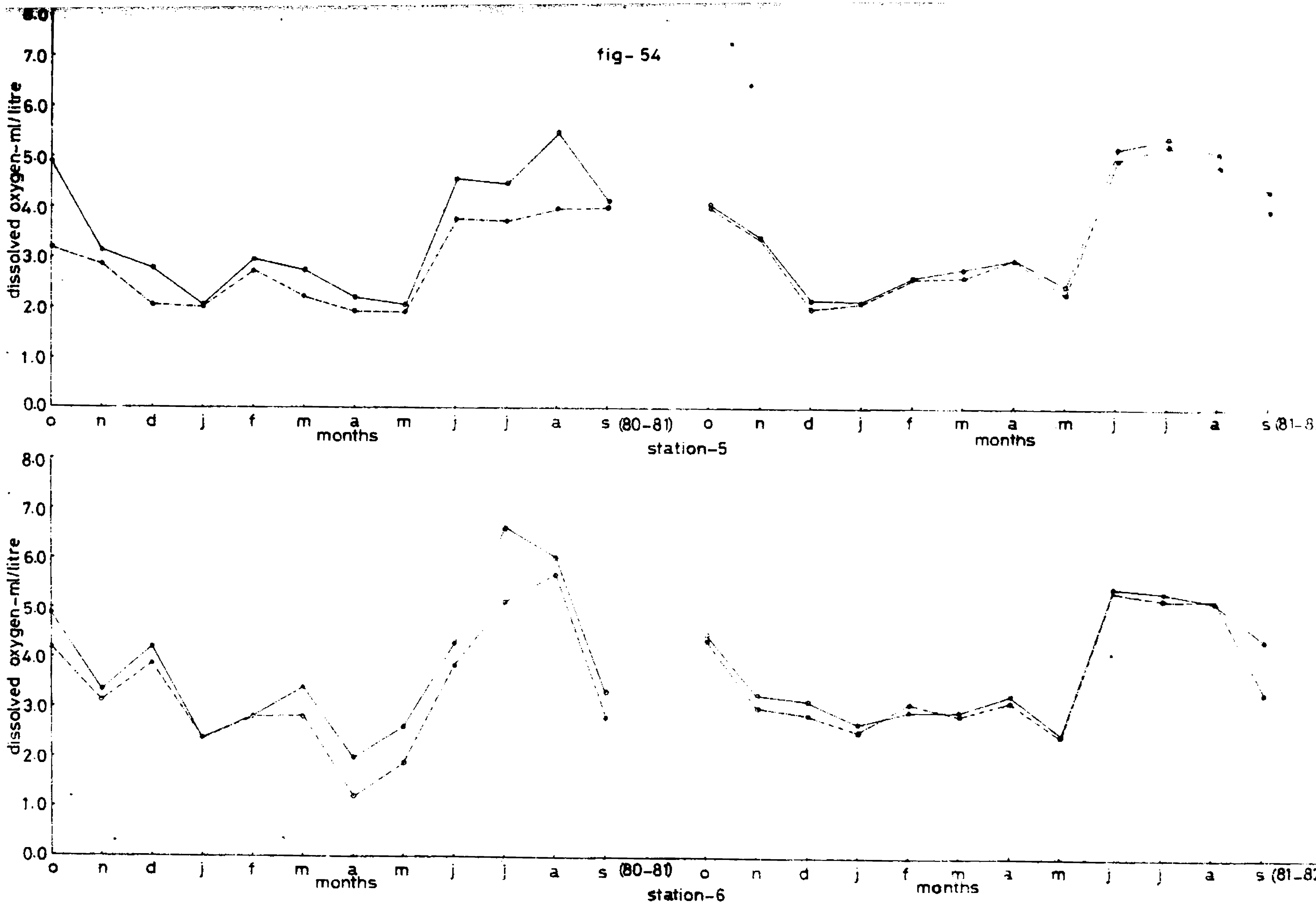
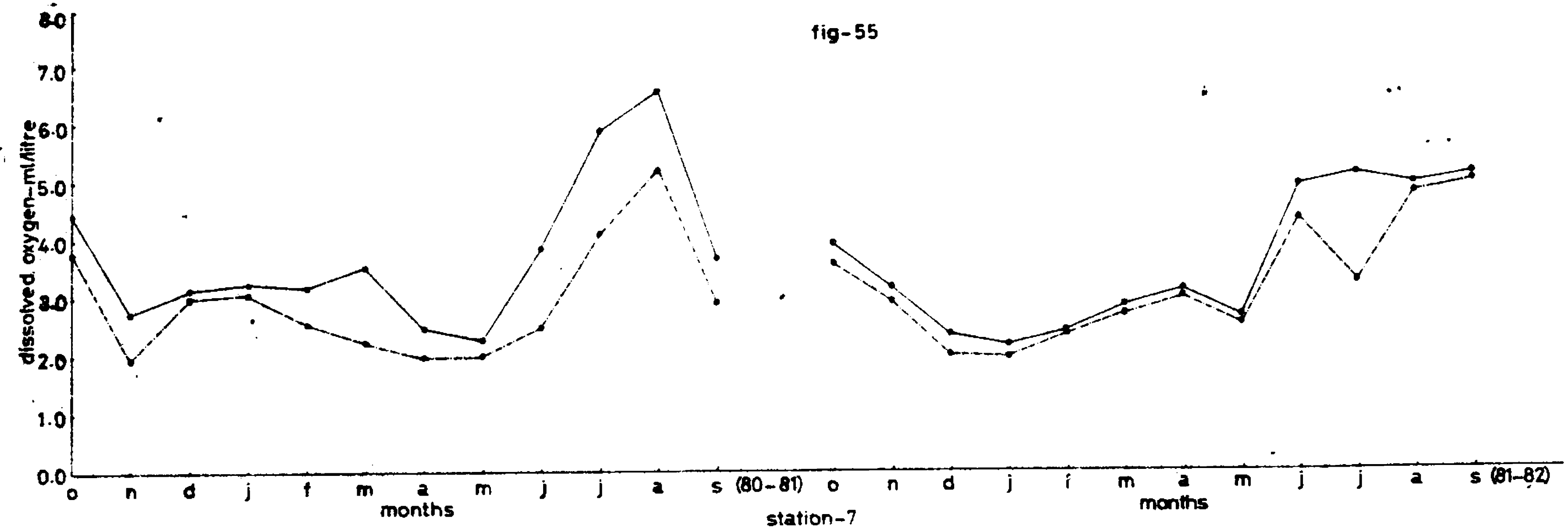
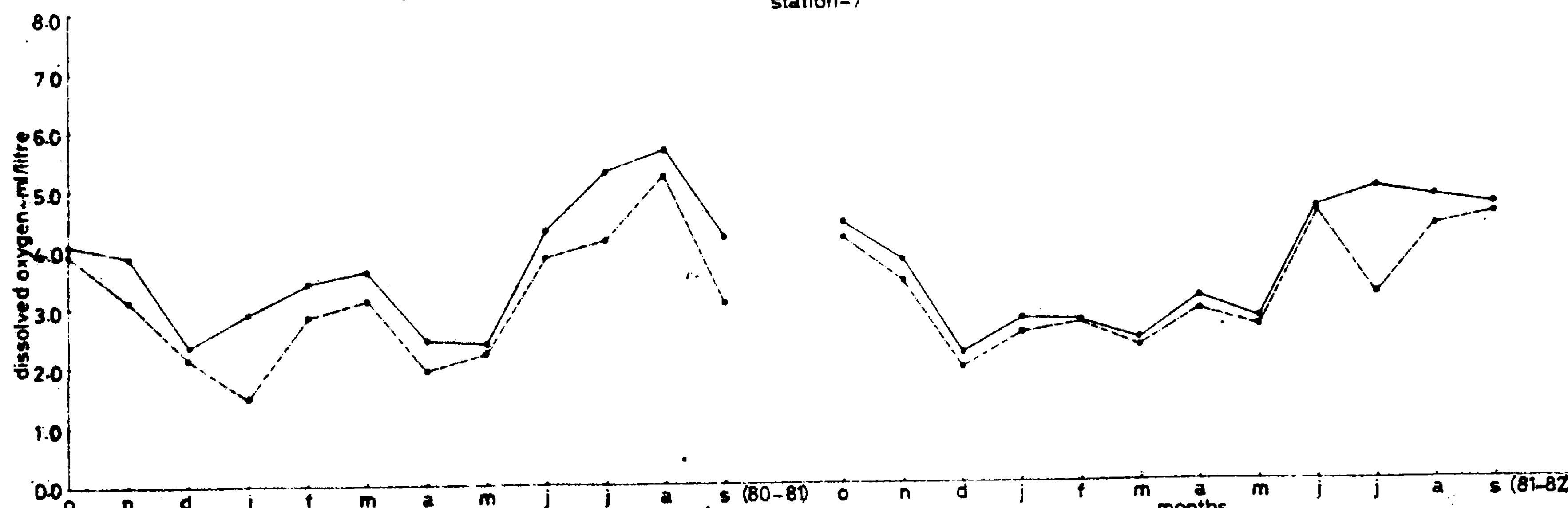

dissolved oxygen-ml/litre
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station-5
station-6

fig- 54

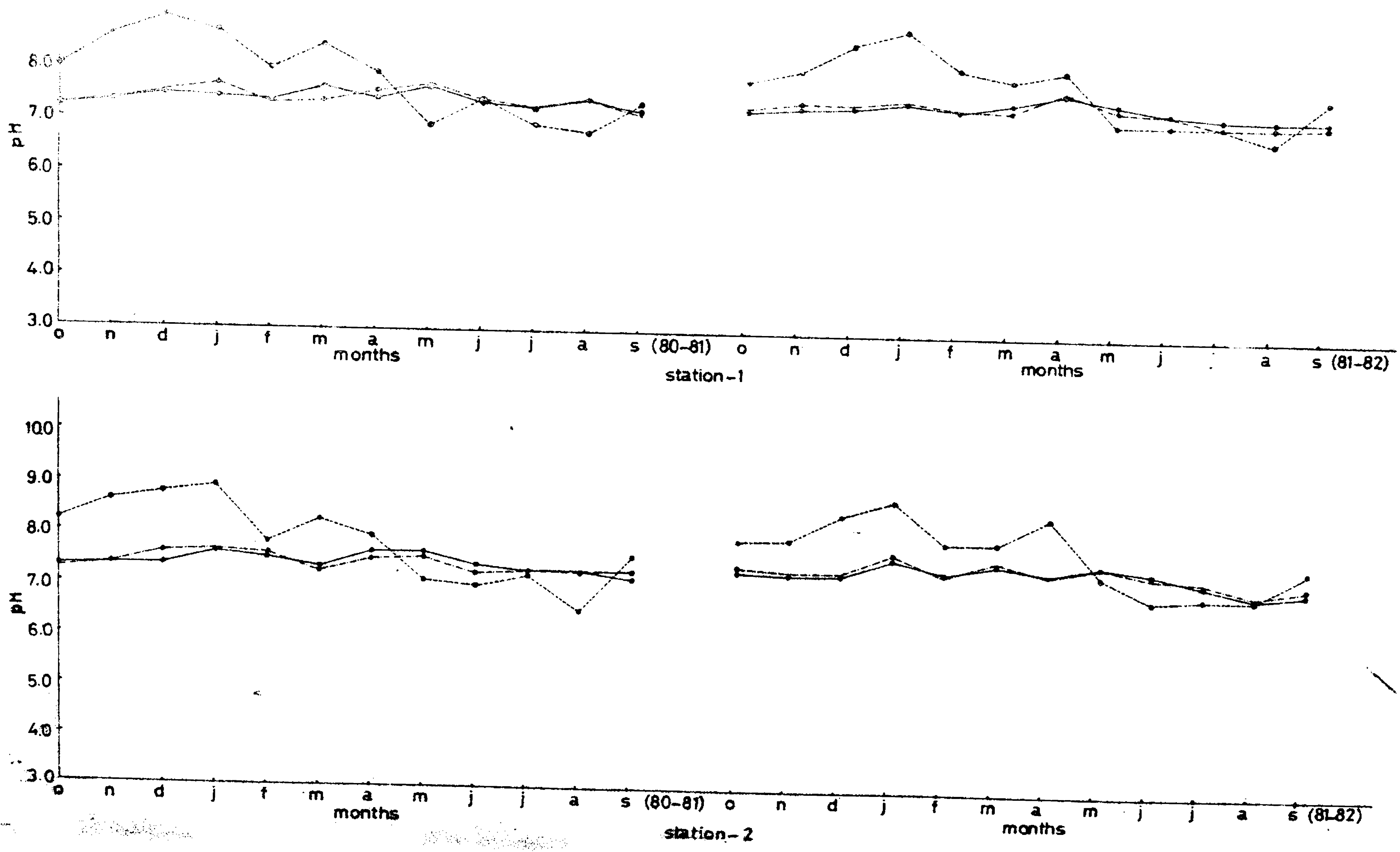
fig-55




station-7




station-8



pH
8.0
7.0
6.0
5.0
4.0
3.0
o n d j f m a m j j a s (80-81)
o n d j f m a m j a s (81-82)
months
station-1
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
o n d j f m a m j j a s (80-81)
o n d j f m a m j j a s (81-82)
months
station-2

fig 57

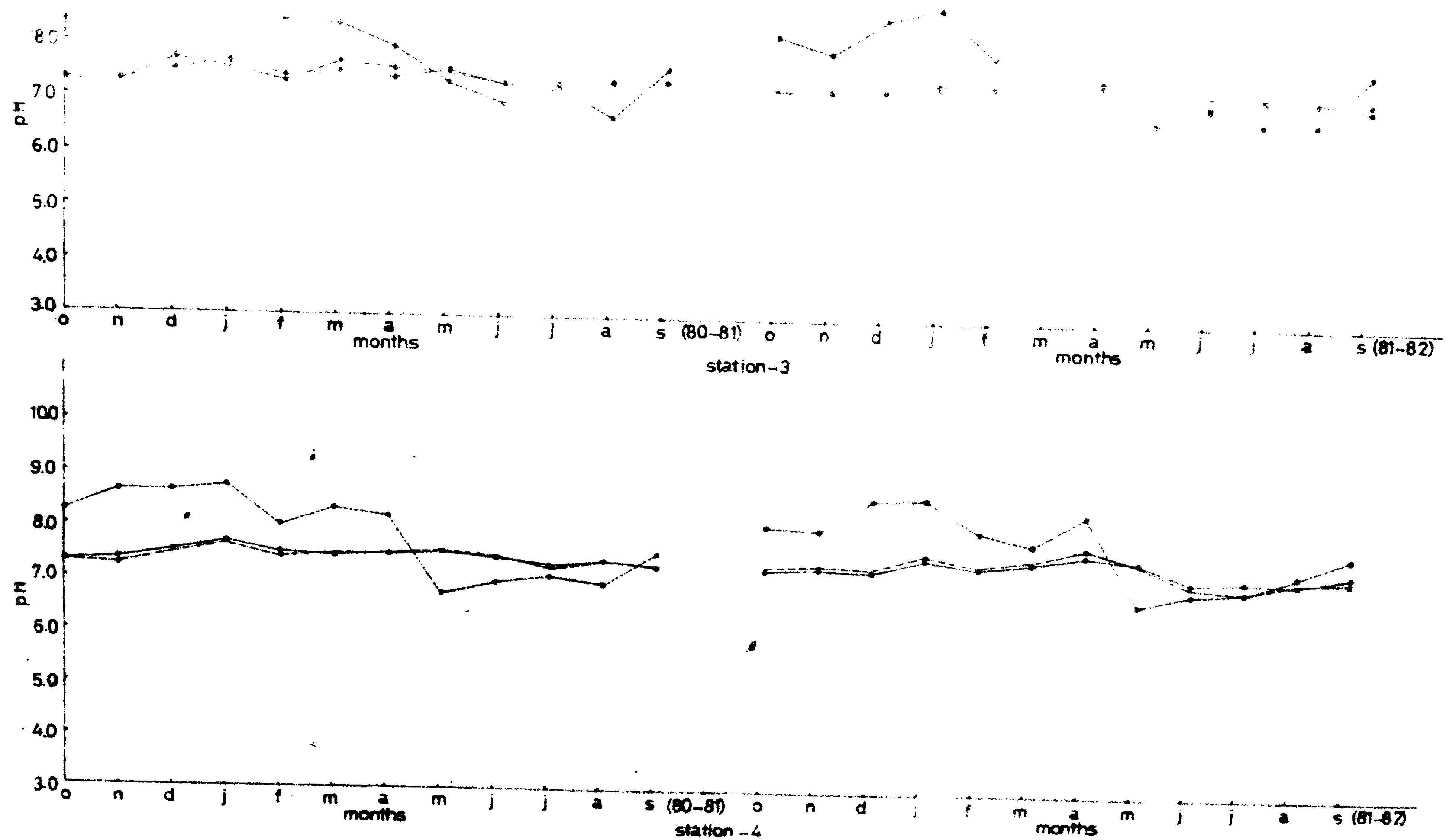
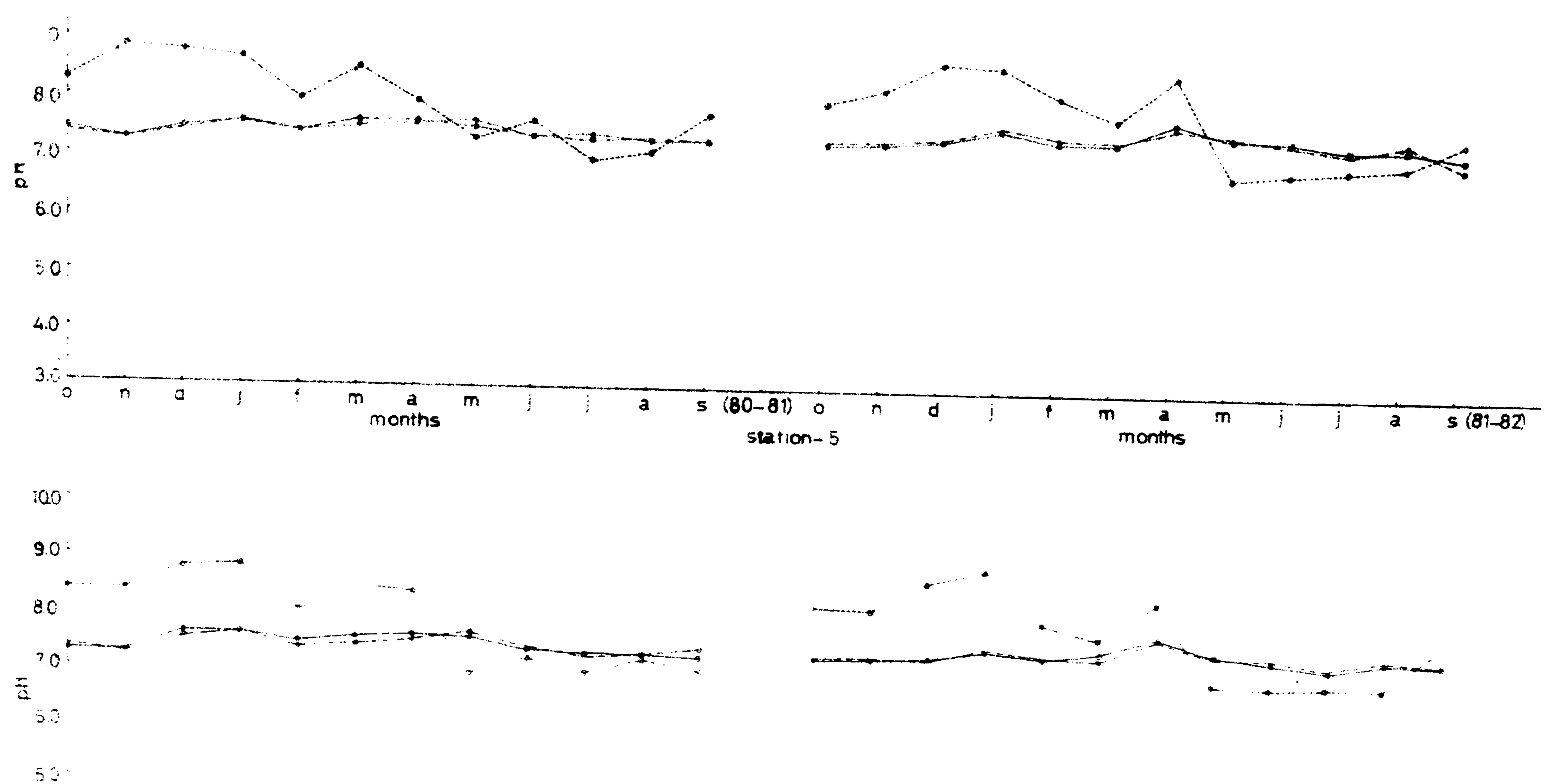

pH
8.0
7.0
6.0
5.0
4.0
3.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
months
station-3
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
months
station-4

Fig - 58



pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
o n d j f m a m j j a s (80–81) o n d j f m a m j j a s (81–82)
months
station- 5
months
pH
10.0
9.0
8.0
7.0
6.0
5.0

fig- 59

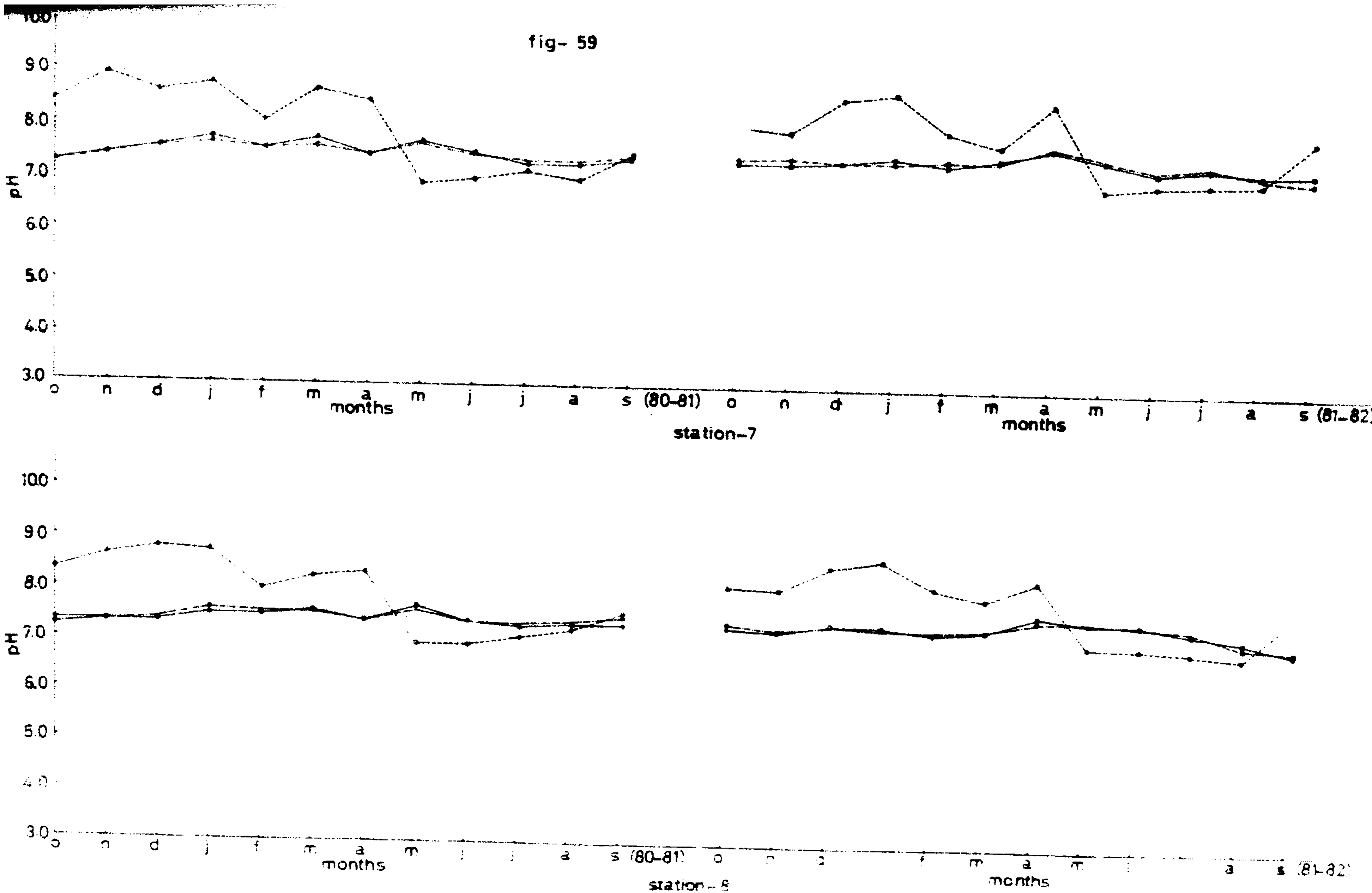
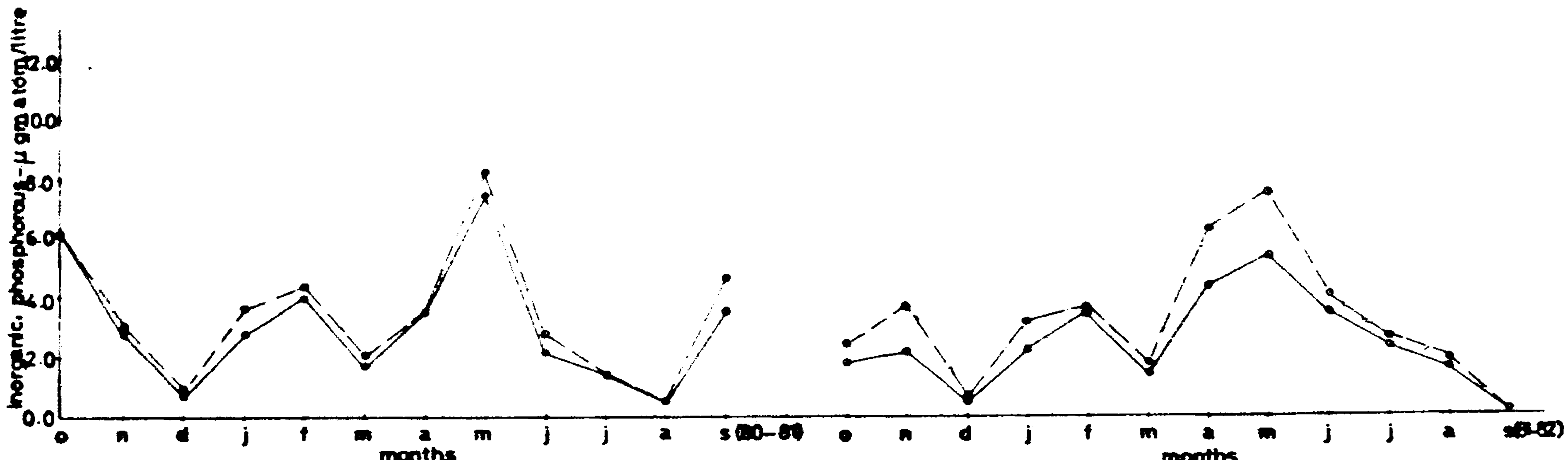
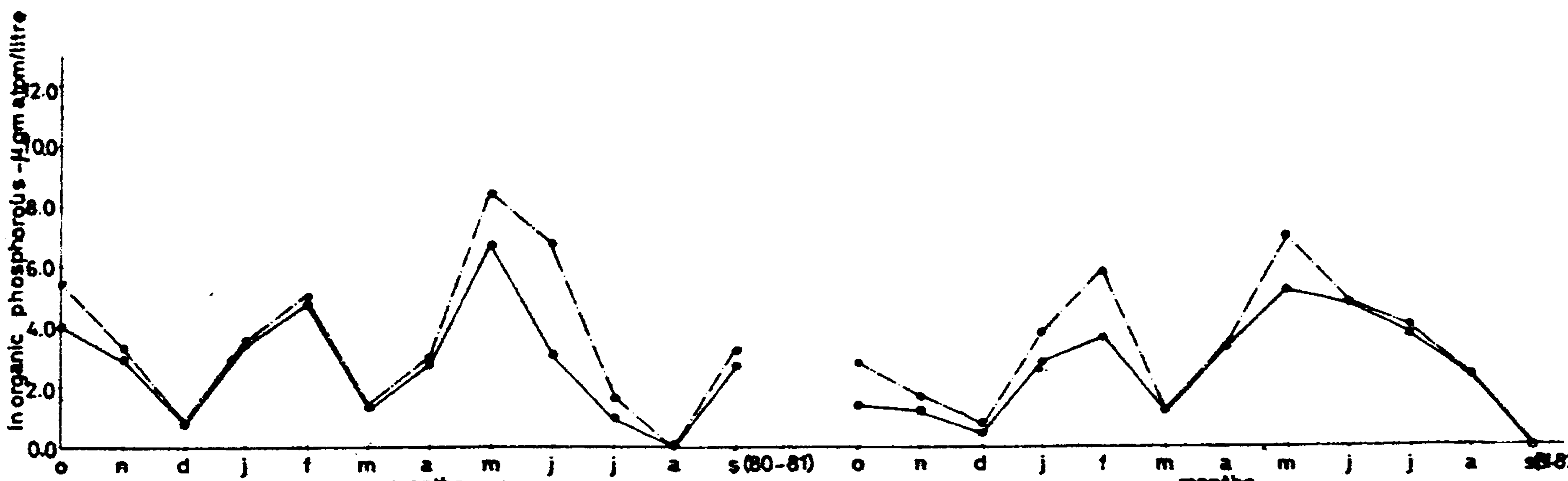

pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
months
station-7
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
o n d j f m a m j j a s (80-81) o n d f m a m a s (81-82)
months
months
station-8

fig - 60

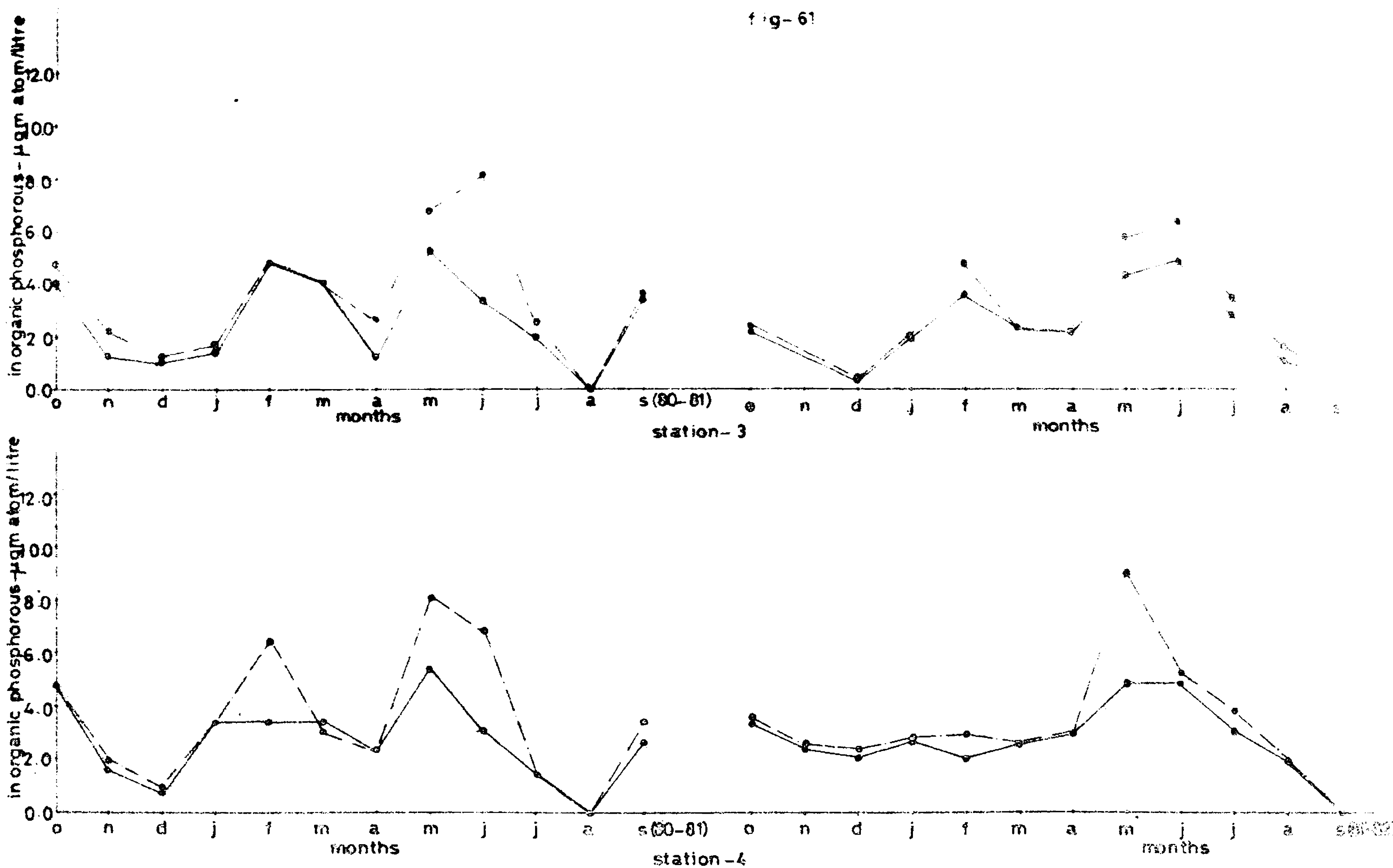



station - 1



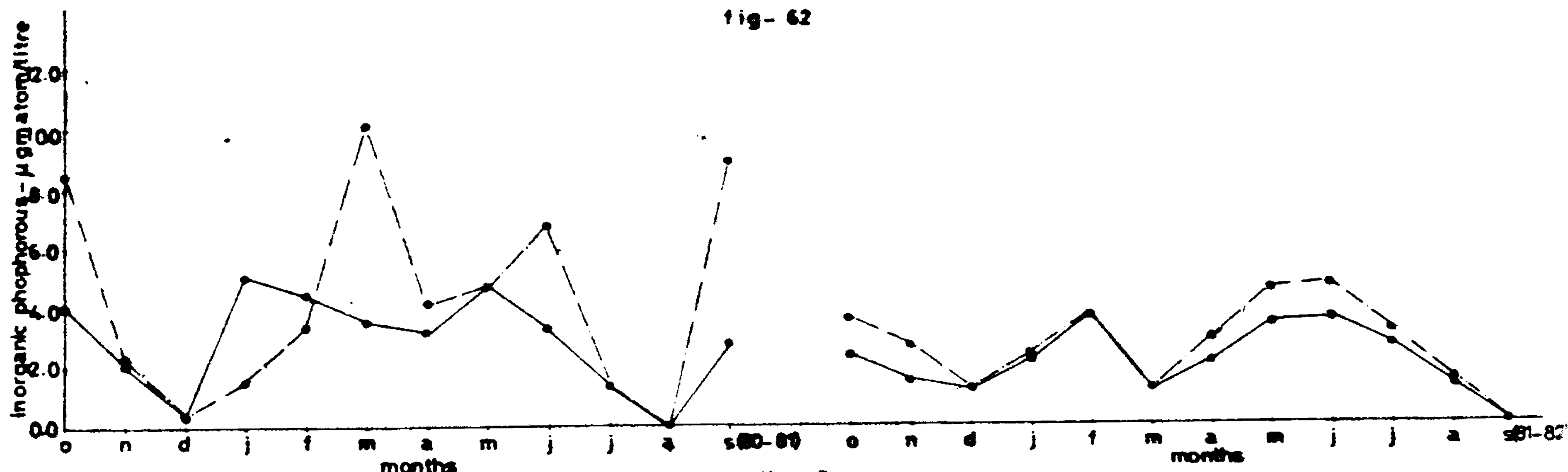

station - 2

fig-61

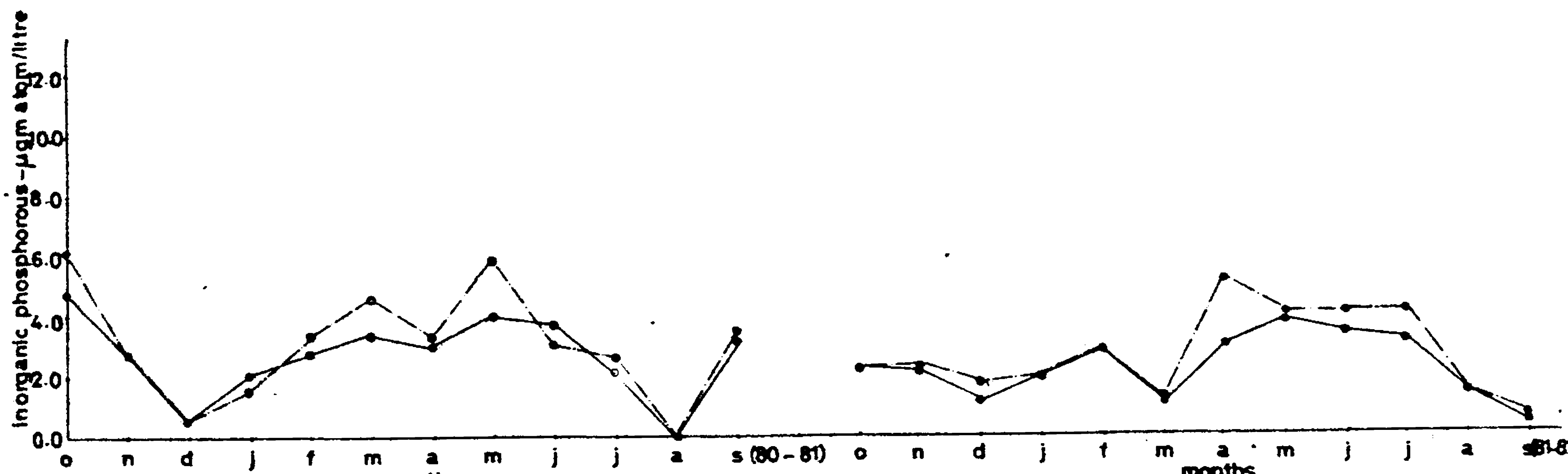


in organic phosphorous - µgm atom/litre
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s(80-81) o n d j f m a m j j a
months
station- 3
months
in organic phosphorous - µgm atom/litre
12.0
10.0
8.0
6.0
4.0
2.0
0.0
o n d j f m a m j j a s(80-81) o n d j f m a m j j a
months
station -4
months

fig- 62

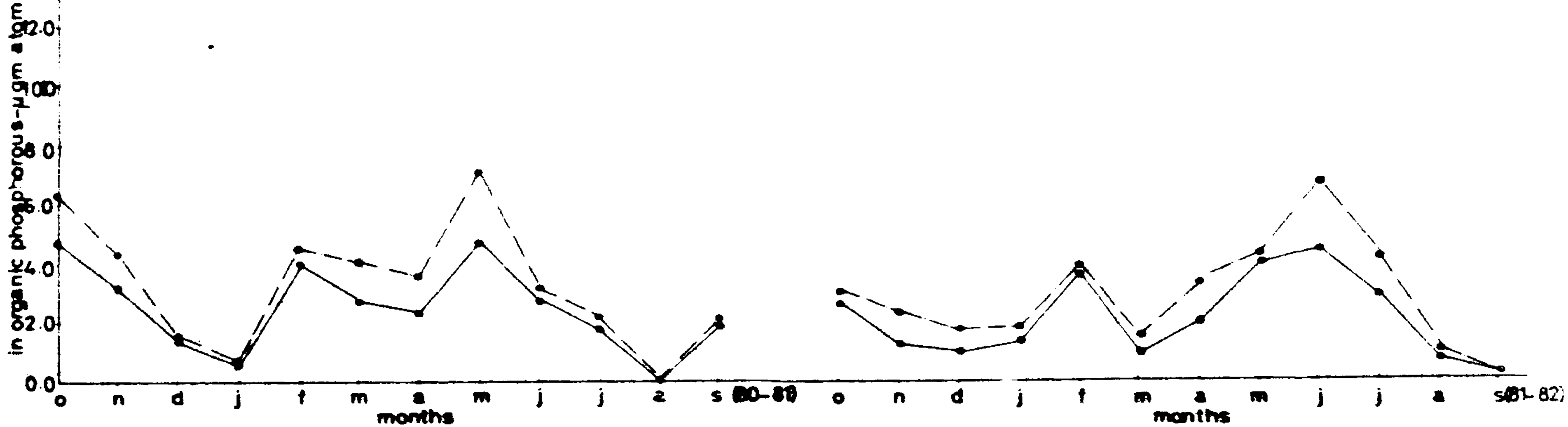



station - 5

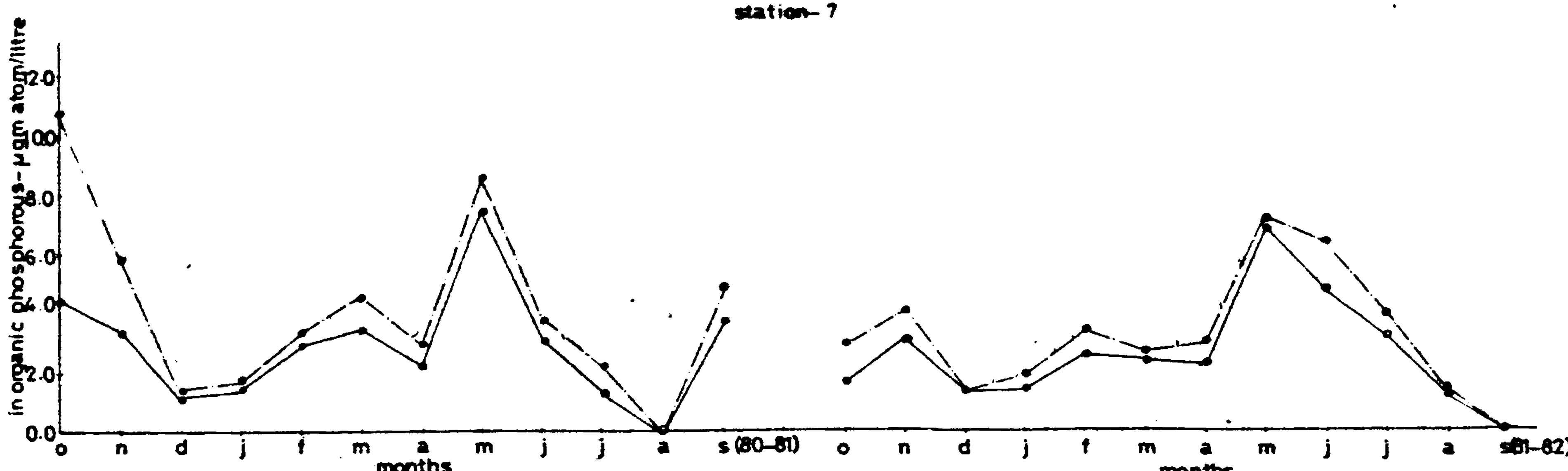



station-6

fig-63

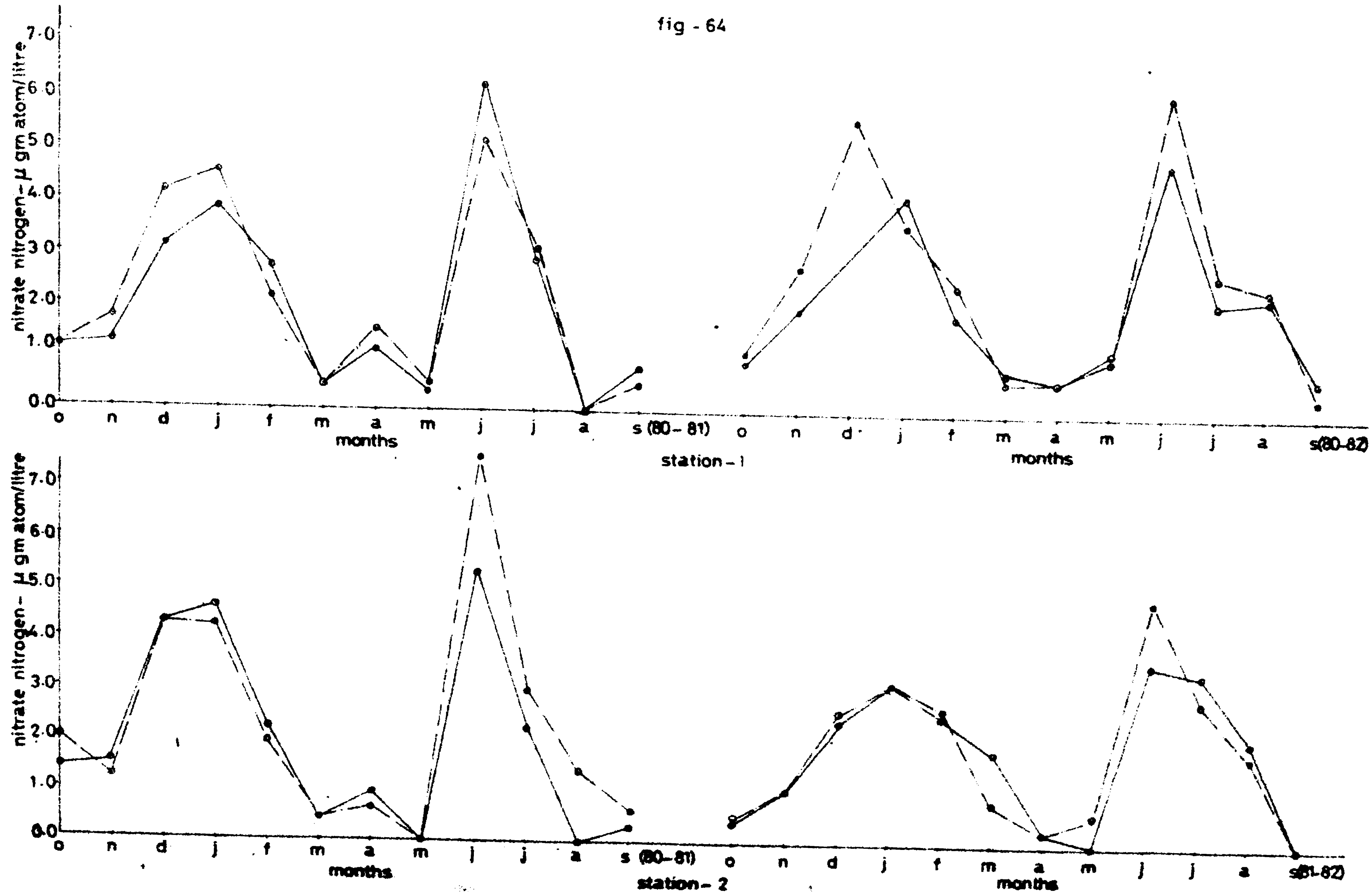



station- 7

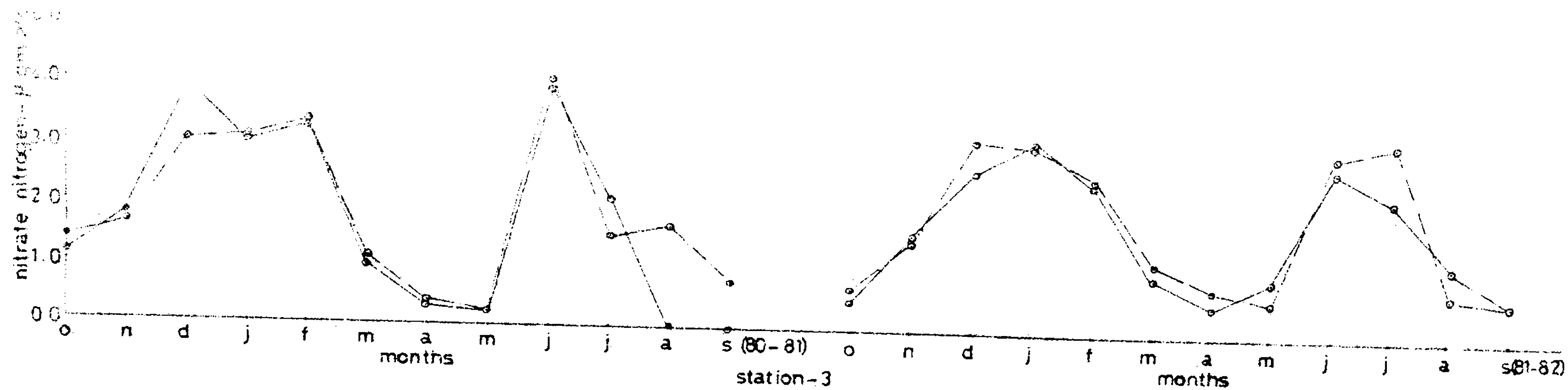



station- 8

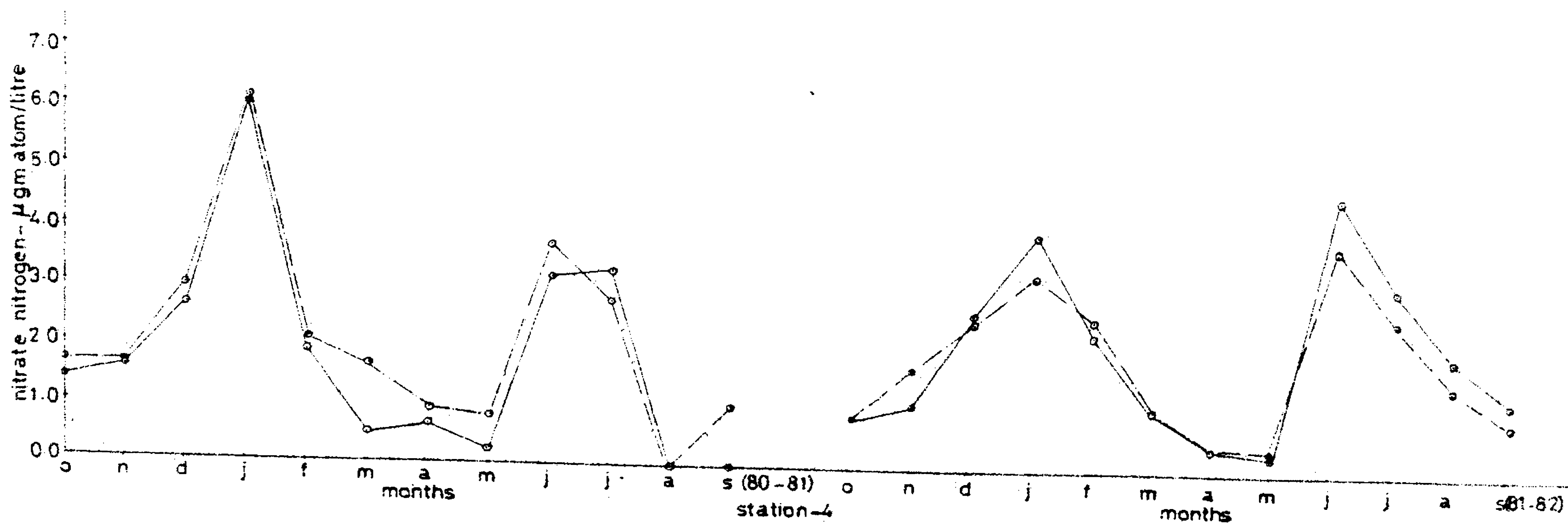
fig - 64



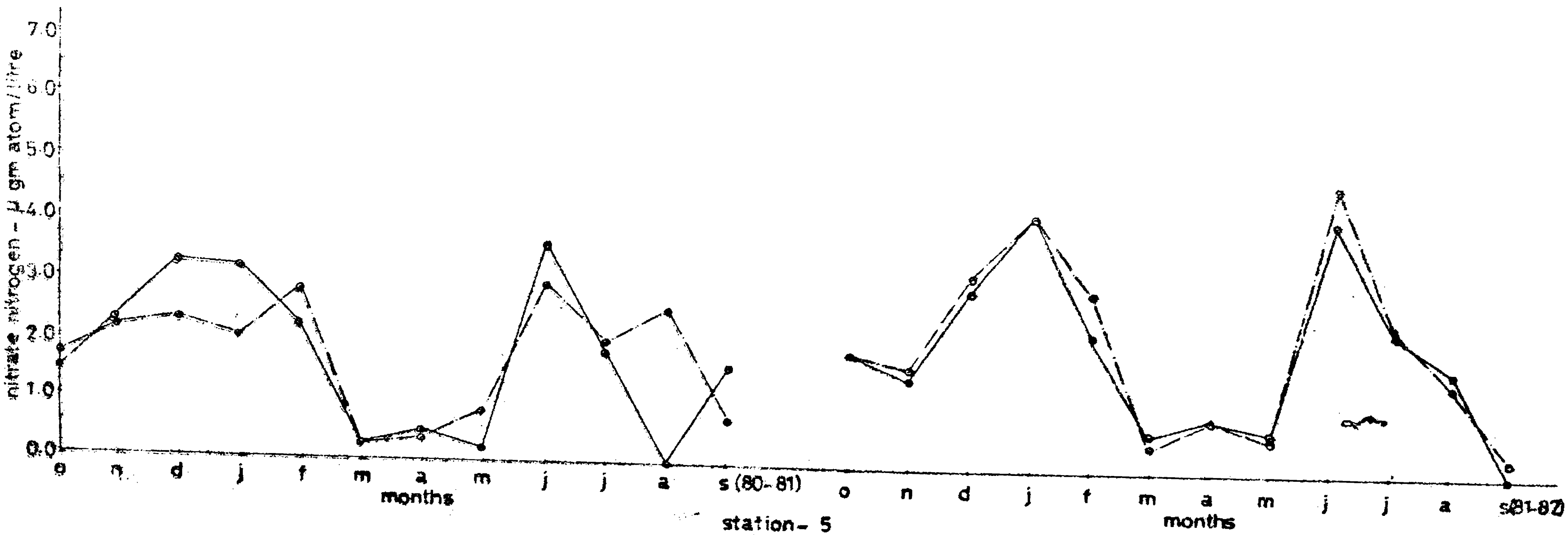
nitrate nitrogen - μ gm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a m j j a s (80 - 81) o n d j f m a m j j a s(80-82)
months
station - 1
months
nitrate nitrogen - μ gm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s(81-82)
months
station - 2
months



nitrate nitrogen - μgm atom/litre
0.0
1.0
2.0
3.0
4.0
o n d j f m a m j j a s (80-81)
months
o n d j f m a m j j a s(81-82)
months
station-3

nitrate nitrogen - μgm atom/litre
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
o n d j f m a m j j a s (80-81)
months
o n d j f m a m j j a s(81-82)
months
station-4


7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
nitrate nitrogen - μ gm atom/litre
o n d j f m a m j j a s (80-81)
months
o n d j f m a m j j a s(81-82)
months
station- 5

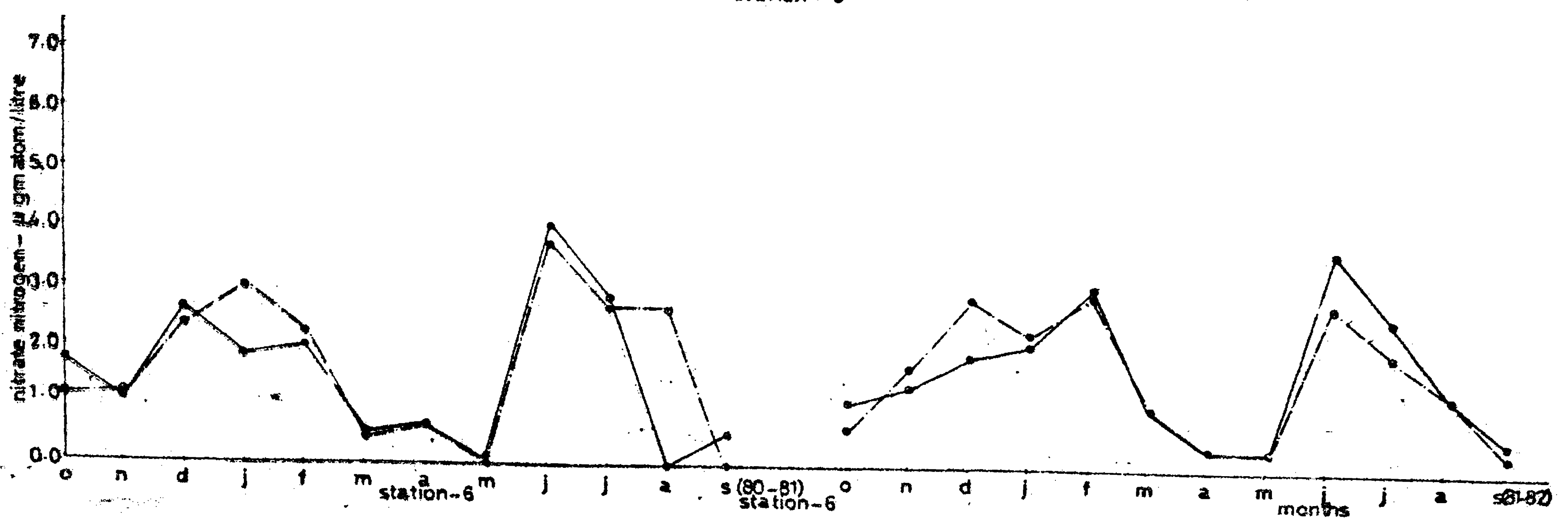

7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
nitrate nitrogen - μ gm atom/litre
o n d j f m a m j j a s (80-81)
station-6
o n d j f m a m j j a s(81-82)
months
station-6

fig-67

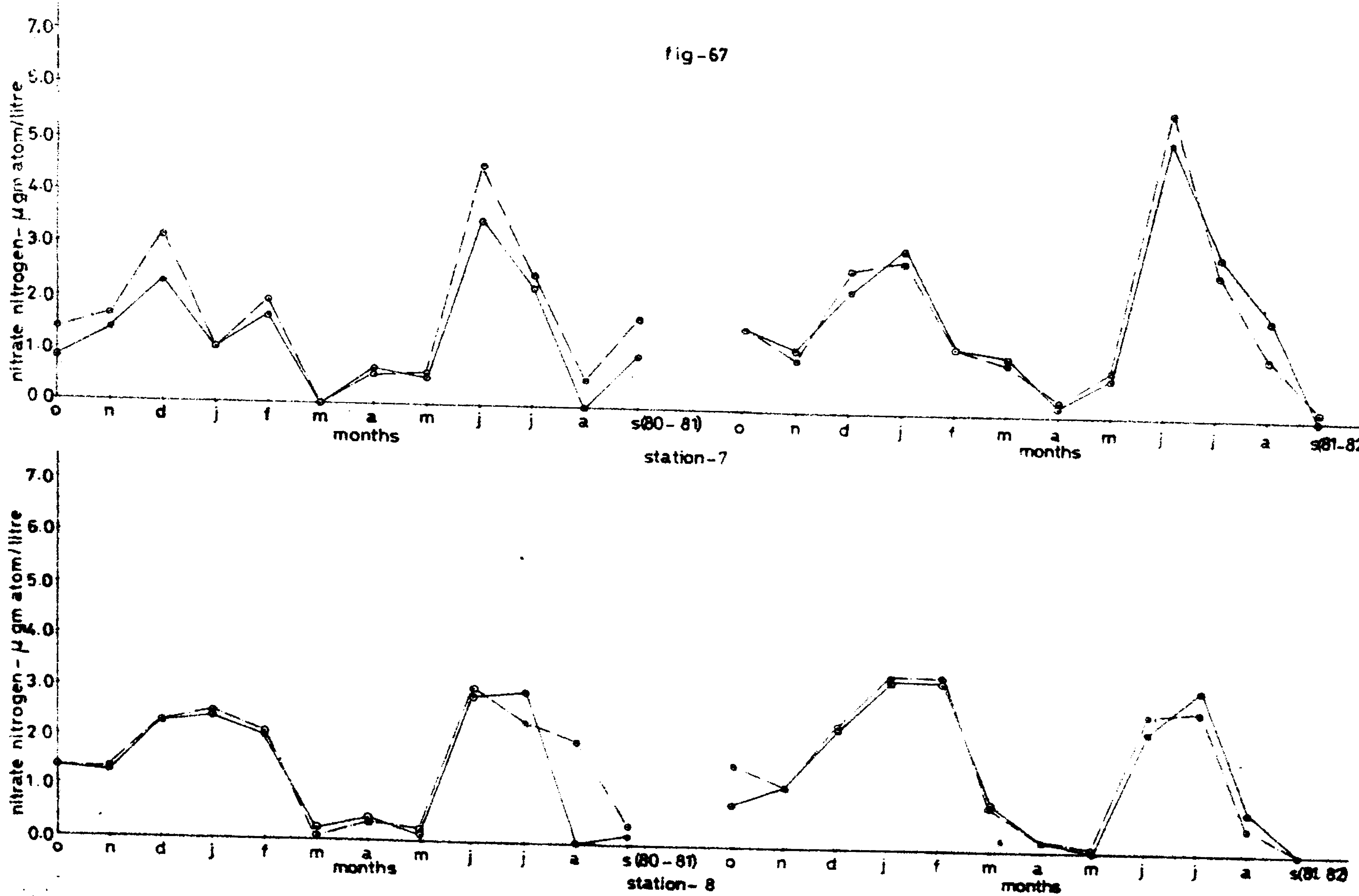
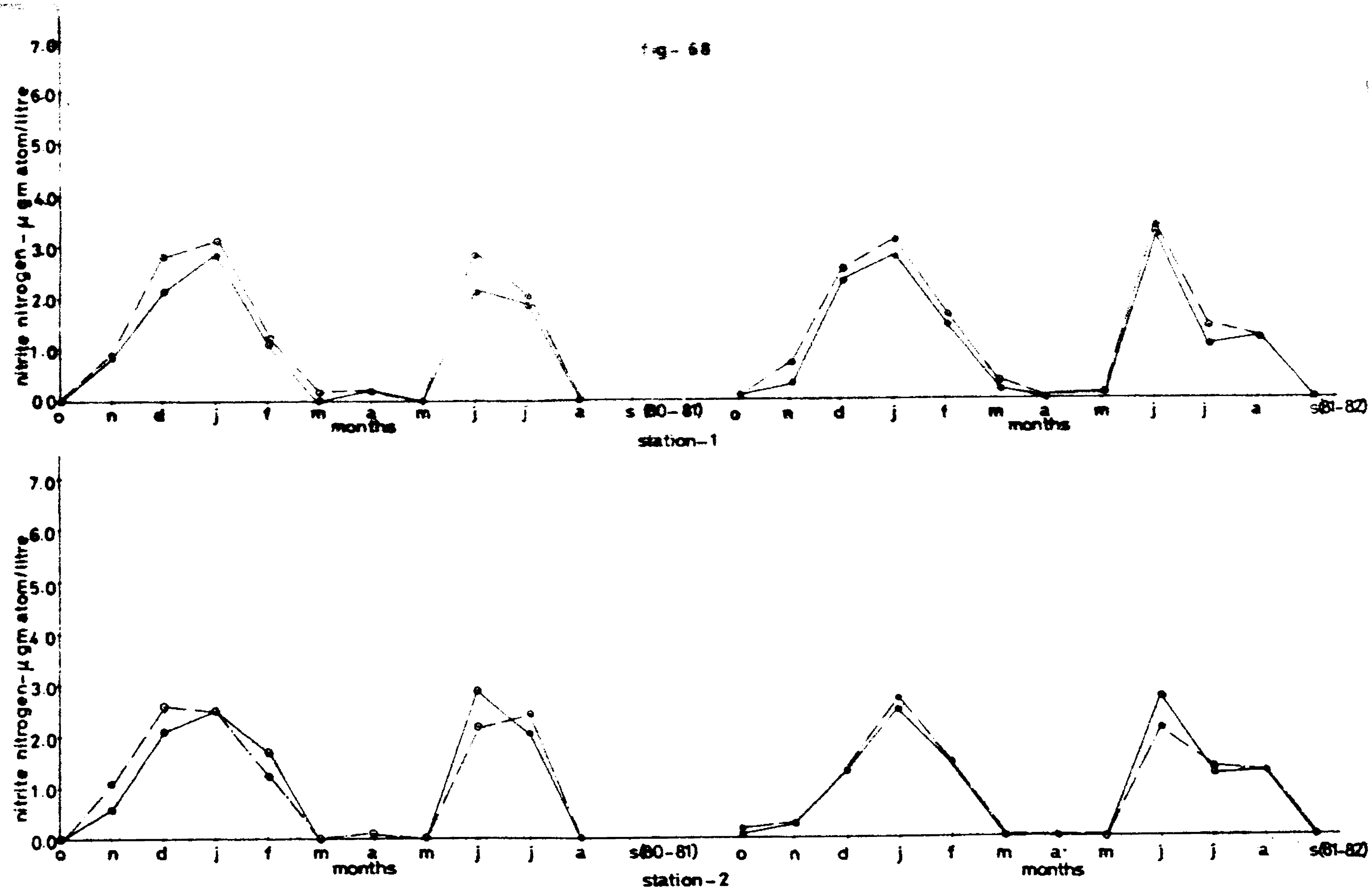
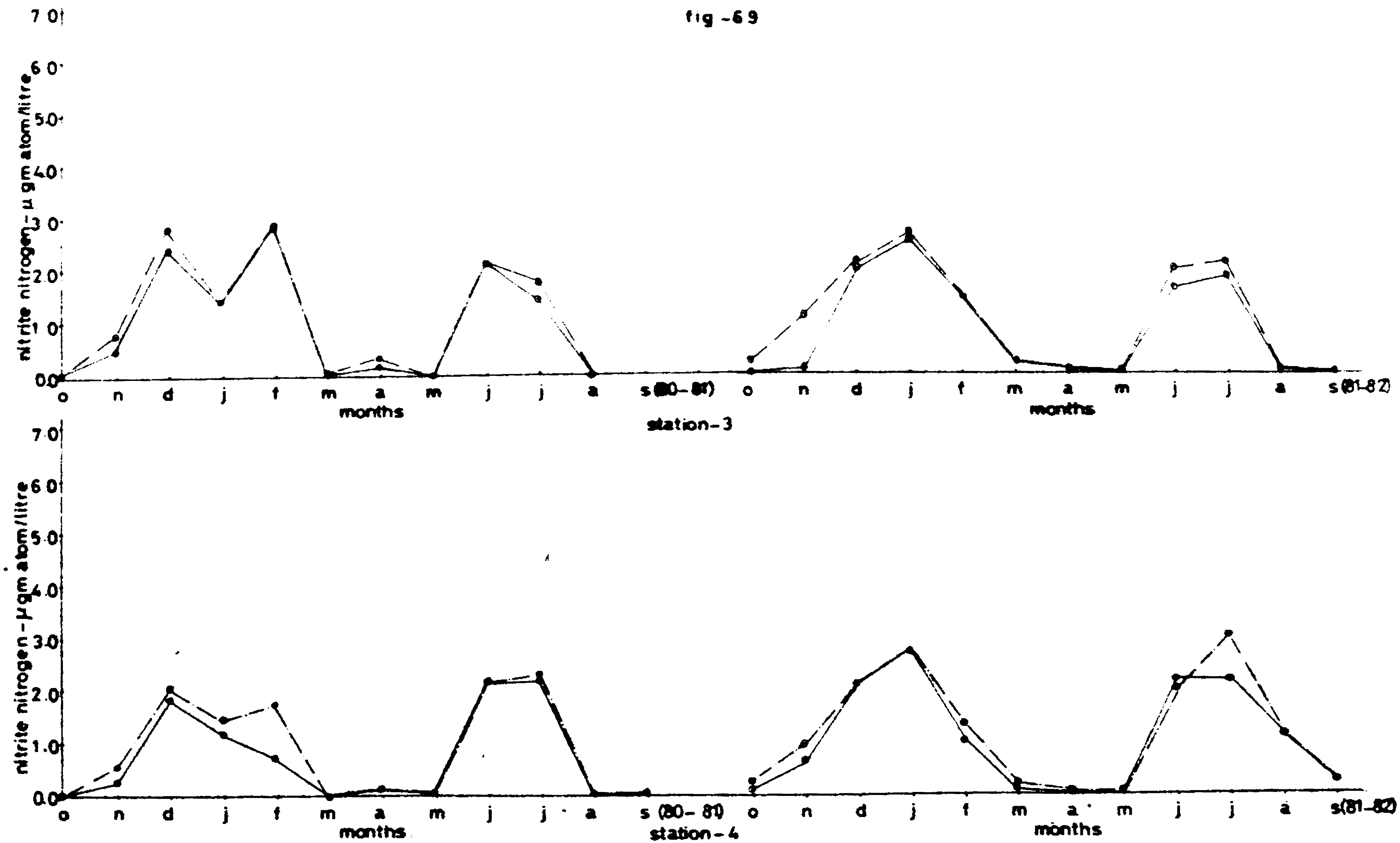

nitrate nitrogen - µ gm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o
n
d
j
f
m
a
m
j
j
a
s(80-81)
o
n
d
j
f
m
a
m
j
j
a
s(81-82)
months
station-7
station-8

fig- 68



7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
nitrite nitrogen - μ gm atom/litre
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s(81-82)
months
months
station-1
station-2

fig -69



nitrite nitrogen - μ gm atom/litre
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station-3
nitrite nitrogen - μ gm atom/litre
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station-4

fig-70

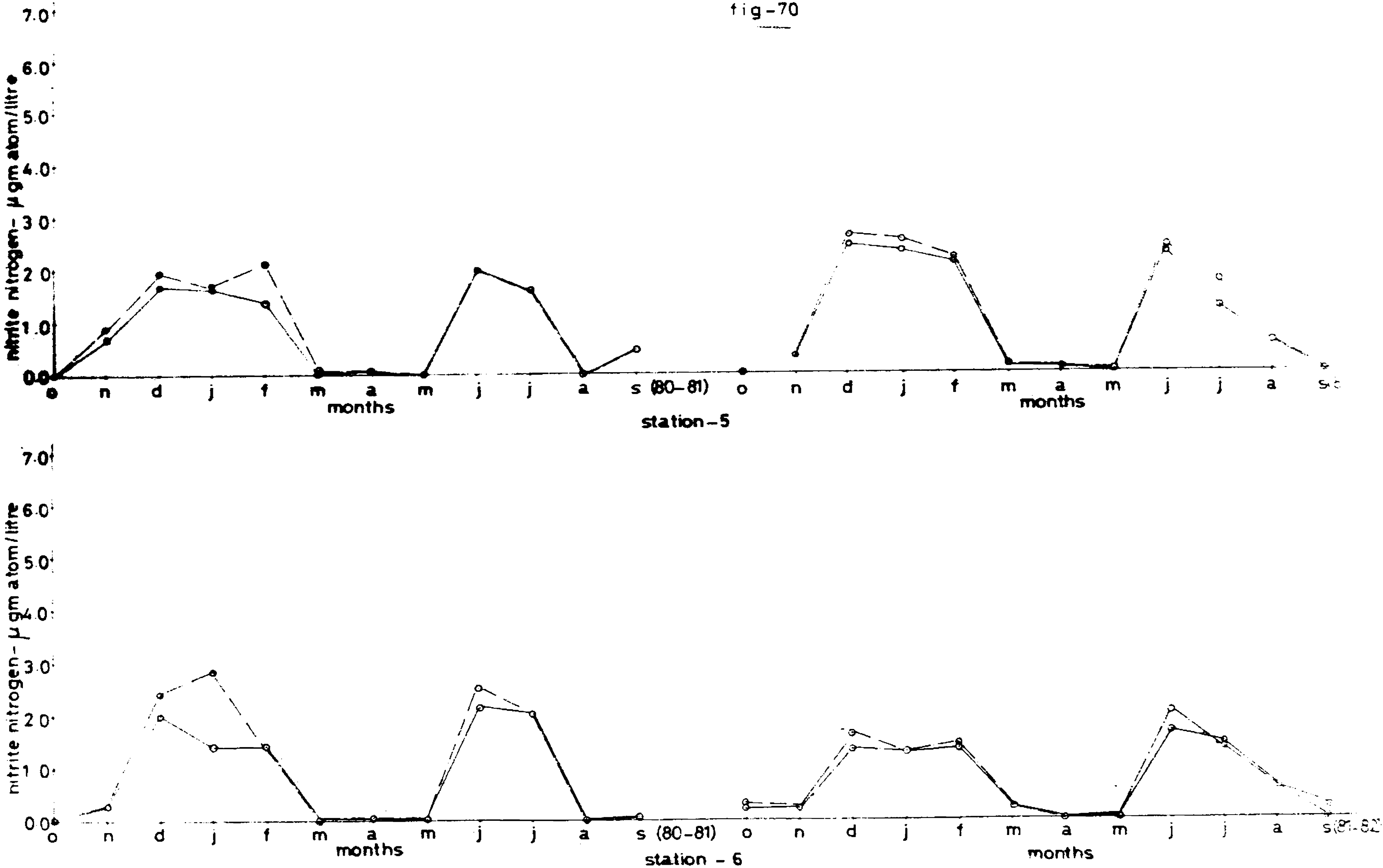
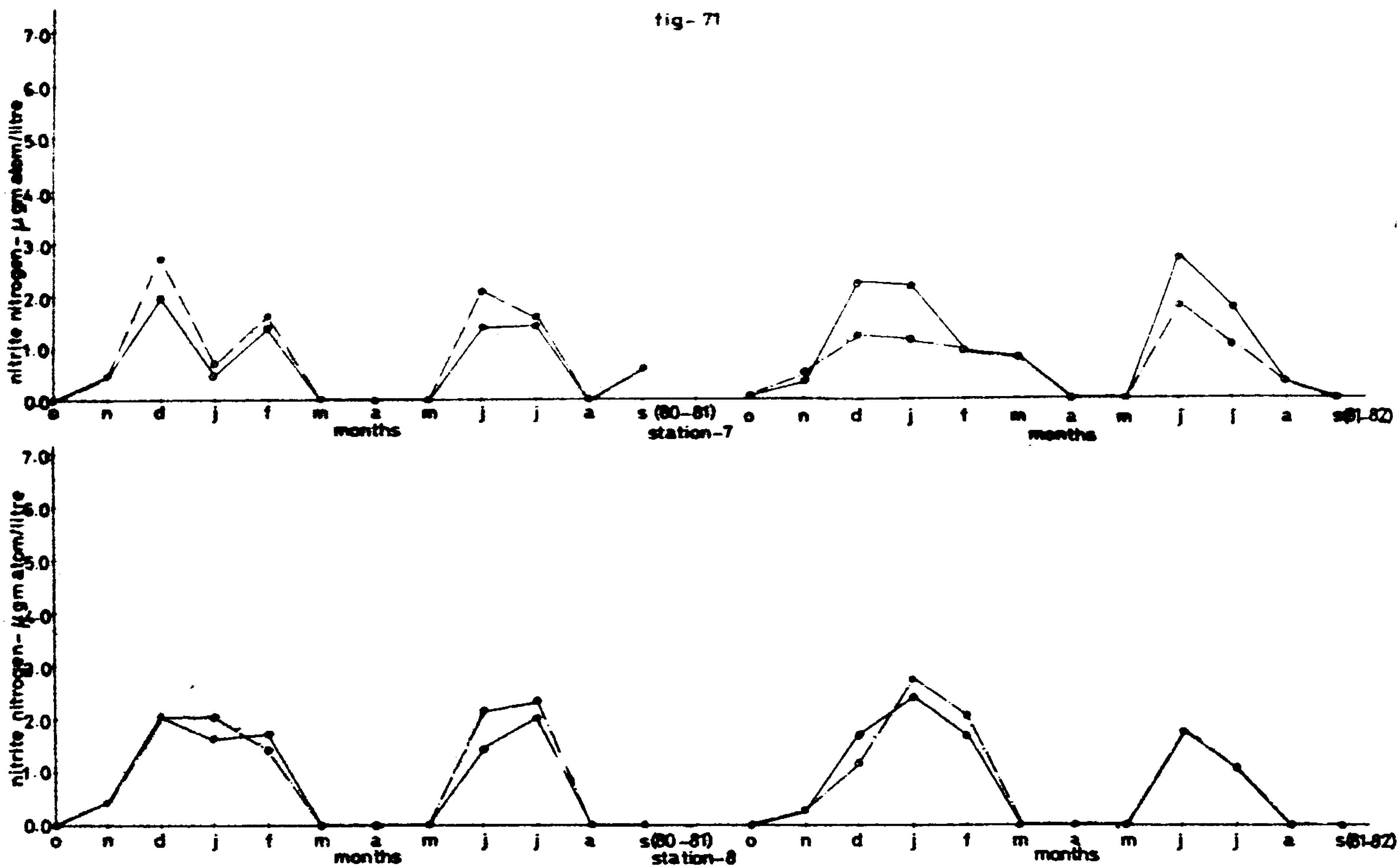
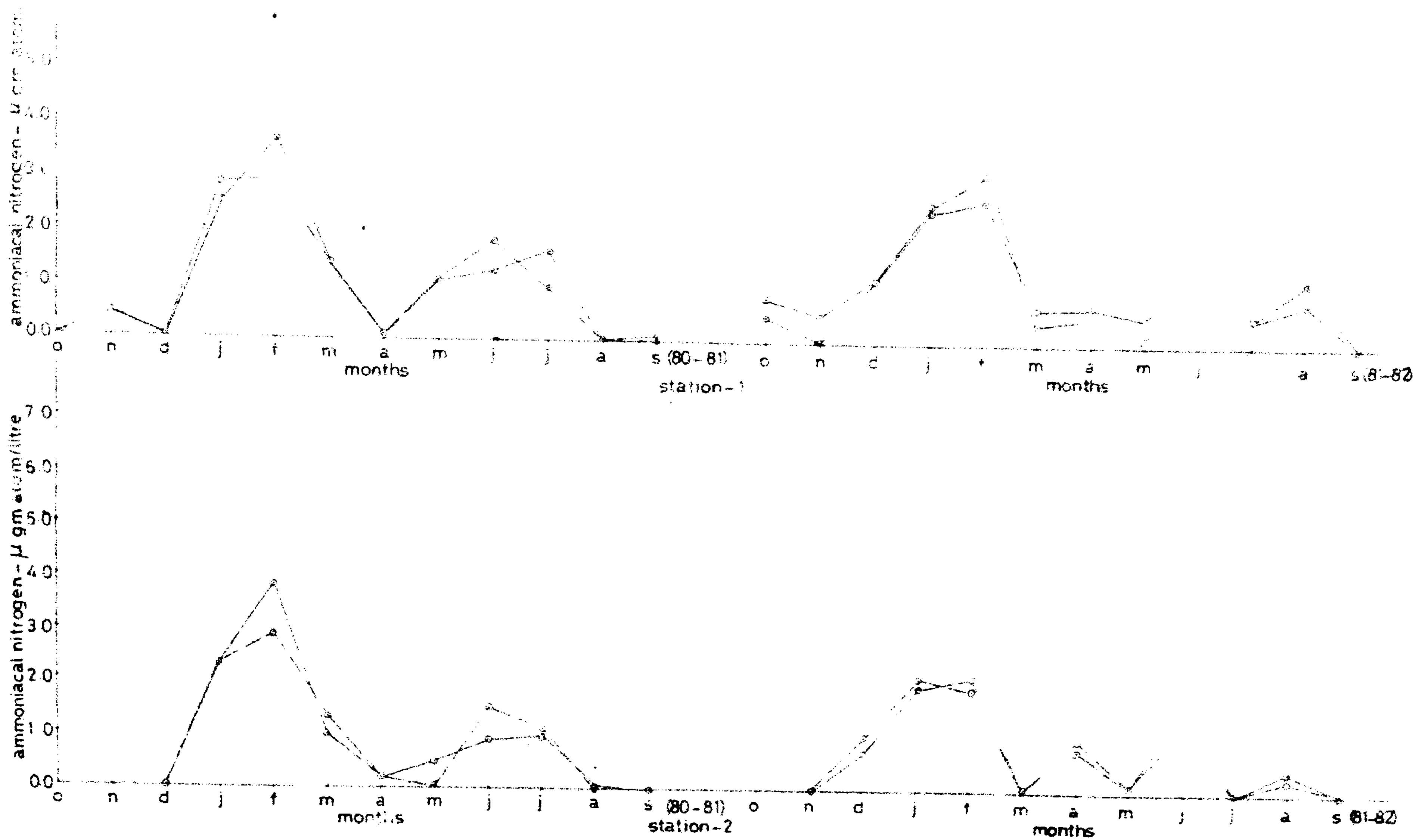

nitrite nitrogen- µgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s
months
months
station-5
nitrite nitrogen- µgm atom/litre
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s(81-82)
months
months
station - 6

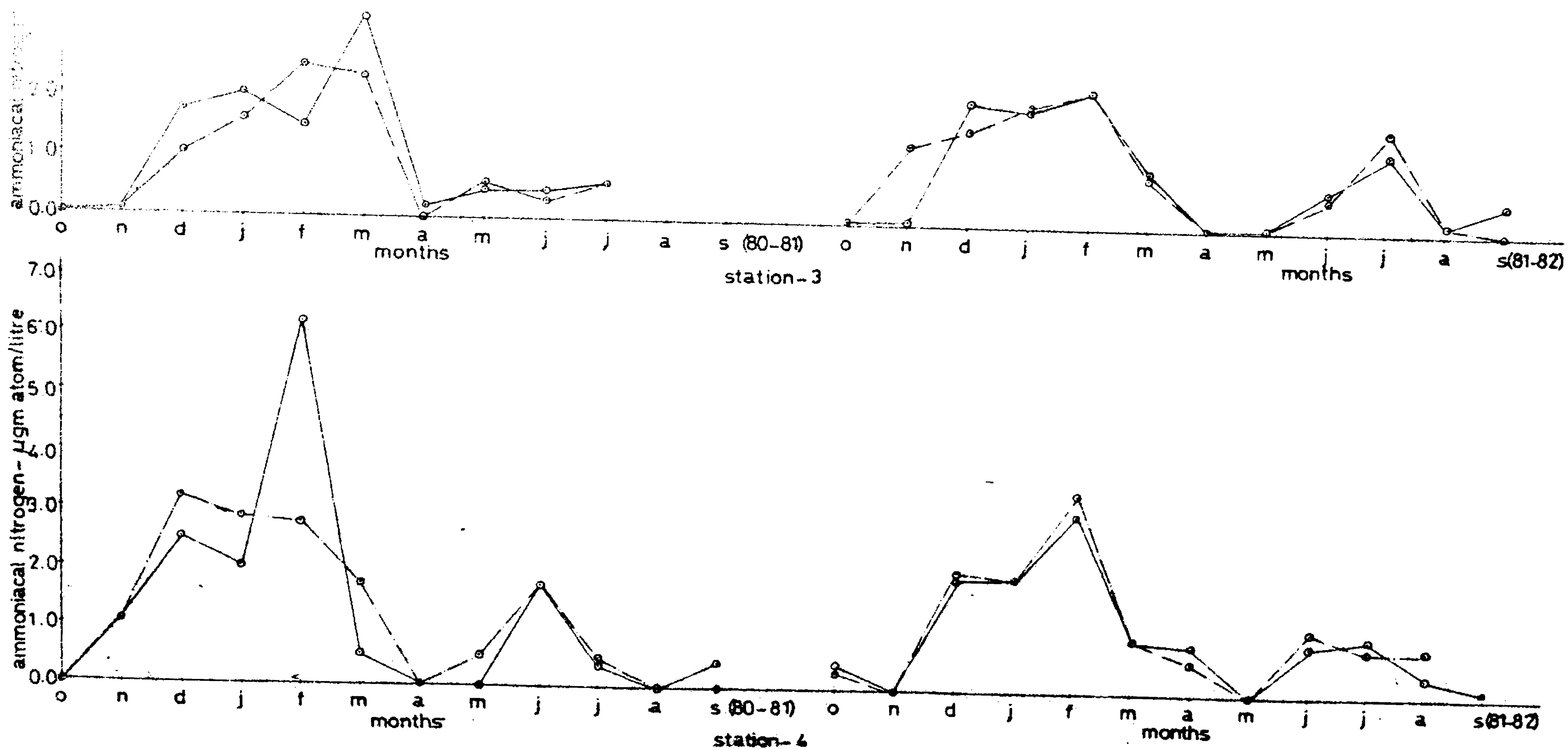
fig- 71

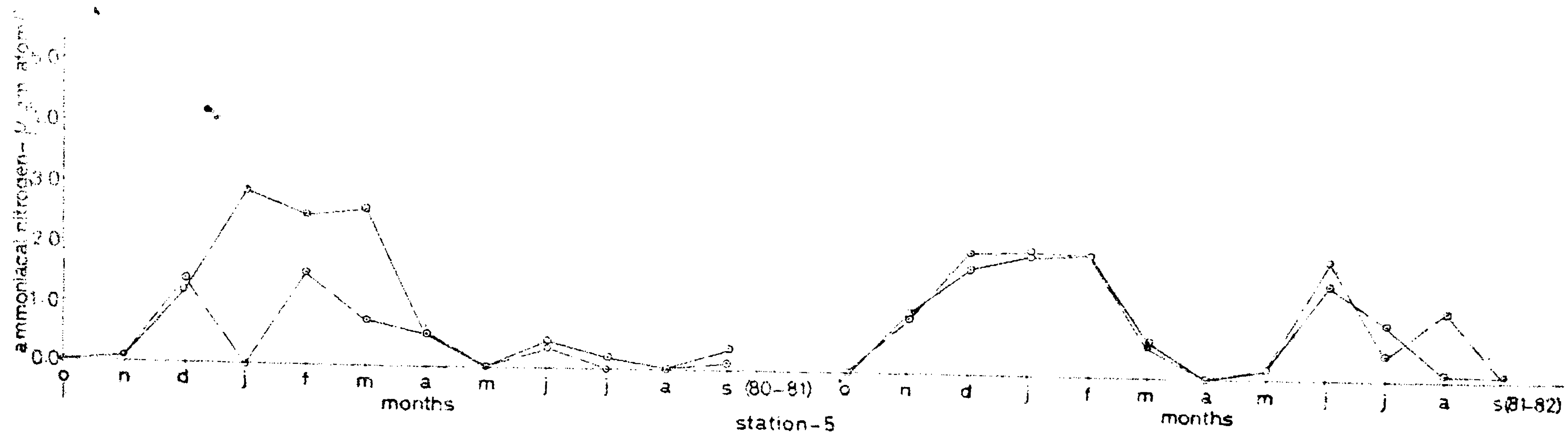


7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
nitrite nitrogen- μ gm atom/litre
o n d j f m a m j j a s (80–81) o n d j f m a m j j a s(81-82)
months
station-7
months
nitrite nitrogen- μ gm atom/litre
o n d j f m a m j j a s(80–81) o n d j f m a m j j a s(81-82)
months
station-8
months

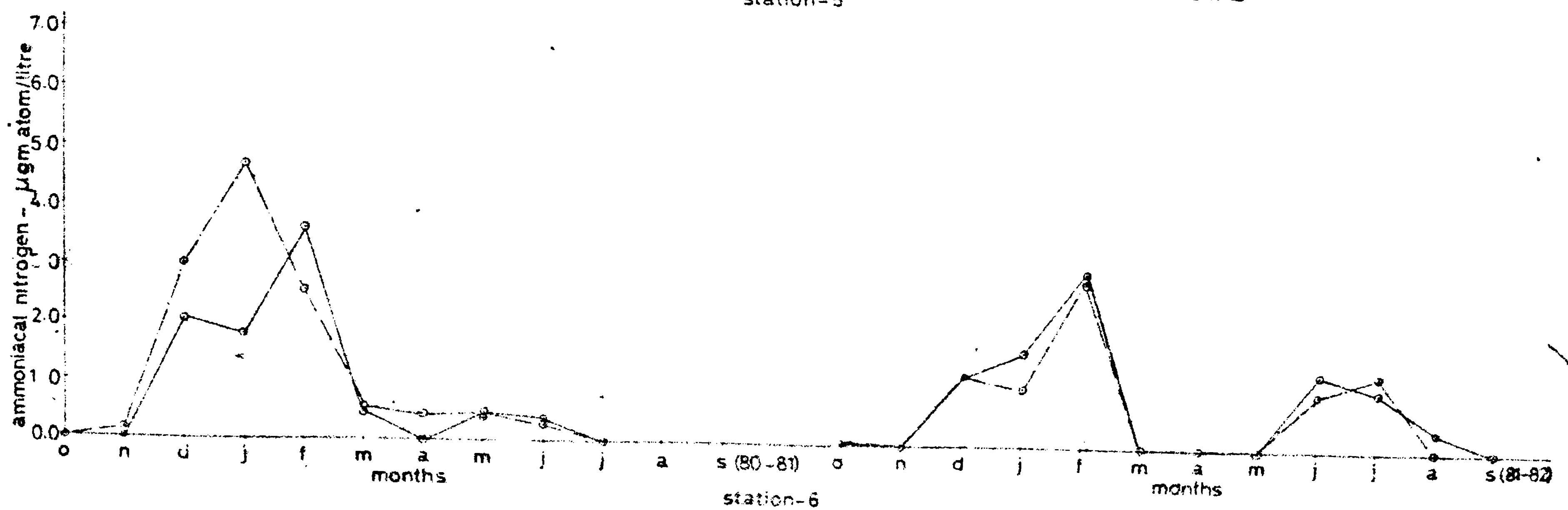


ammoniacal nitrogen - µ gm atom/litre
0.0
1.0
2.0
4.0
o n d j f m a m j j a s (80-81) o n d j f m a m j a s (81-82)
months
station-1
ammoniacal nitrogen - µ gm atom/litre
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s (81-82)
months
station-2


ammoniacal nitrogen - µgm atom/litre
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
o n d j f m a m j j a s (80-81) o n d j f m a m j j a s(81-82)
months
station-3
station-4

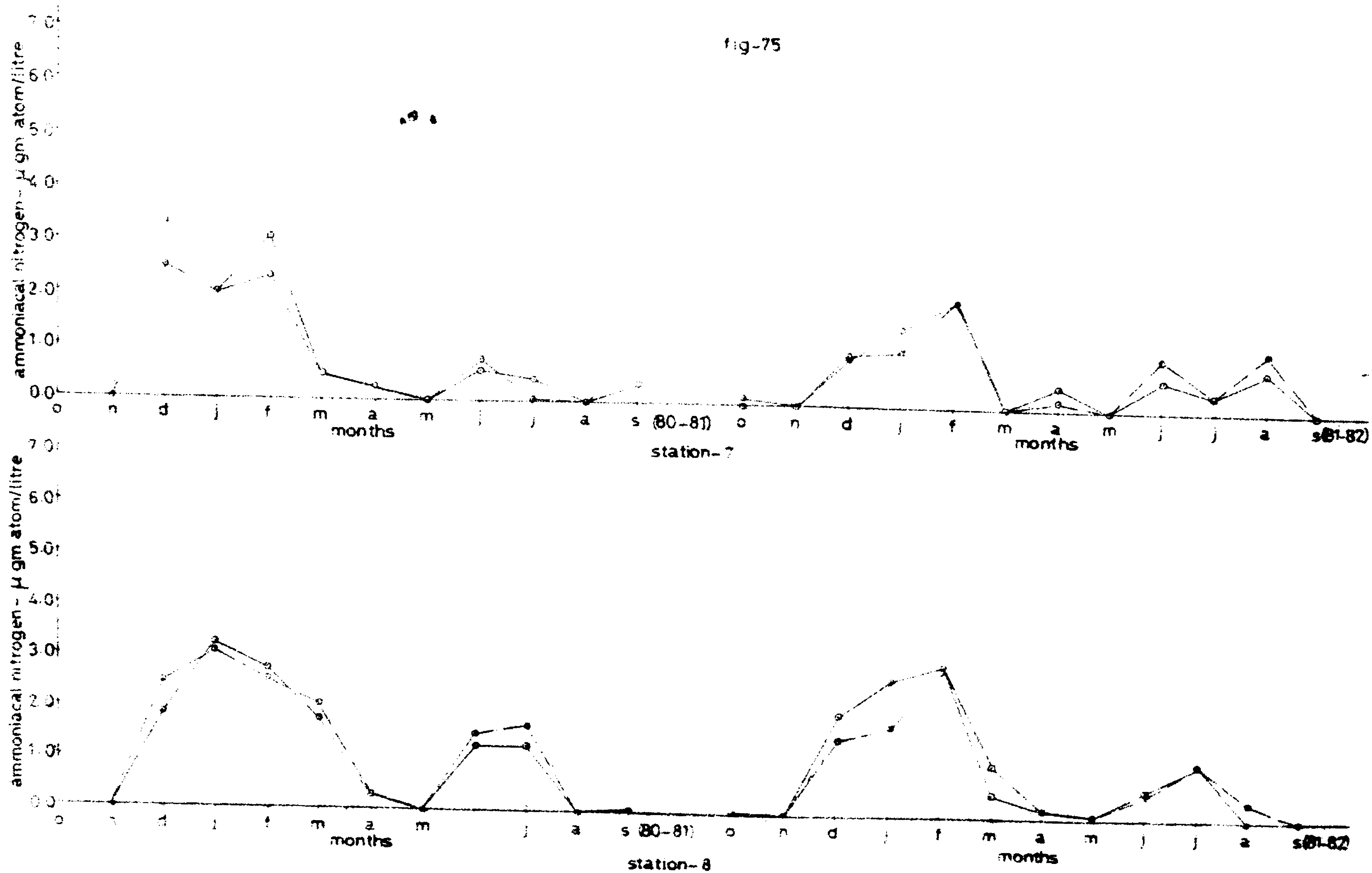


ammoniacal nitrogen – µgm atom/litre
0.0
1.0
2.0
3.0
o n d j f m a m j j a s (80–81) o n d j f m a m j j a s(81-82)
months
station-5

ammoniacal nitrogen – µgm atom/litre
0.0
1.0
2.0
4.0
5.0
6.0
7.0
o n d j f m a m j j a s (80–81) o n d j f m a m j j a s(81-82)
months
station-6

fig-75



ammoniacal nitrogen - μ gm atom/litre
months
station-7
s(80-81)
s(81-82)
ammoniacal nitrogen - μ gm atom/litre
months
station-8

# CHAPTER XI

## MACROBENTHOS IN THE PRAWN FILTERING FIELD

### INTRODUCTION

Investigation on the food and feeding habits of prawns has revealed that a number of commercially important species are omnivores and detritus feeders. They feed actively on the benthic organisms. This finding has resulted in an accelerated interest in the study of the benthos in relation to various environmental parameters and prawn fishery. Thus now it is a well established fact that brackish water ponds with high benthic productivity are potential areas for prawn culture.

Based on the size of the organisms, early workers (Mortensen, 1925; Remane, 1933) divided benthos into microbenthos and macrobenthos. Later in 1942, Mare coined the term meiobenthos to denote organisms of intermediate size.

Depending on the nature of the substratum and productivity of the overlying water benthic production also varies. Again the numerical abundance and diversity of the species are dependent on a number of environmental parameters. Extensive areas are at present used for prawn culture. In the seasonal field prawn culture and paddy cultivation are done alternatively whereas perennial fields are permanent culture fields. Despite the keen interest shown by the people for prawn culture, information on the benthic productivity, species abundance and diversity are meagre.

## MATERIALS AND METHODS

During the present study the macrobenthos were collected from a seasonal field and a perennial field, every month for two seasons from pre-fixed station. Samples were taken from four stations in the seasonal field and from eight stations in the perennial field. The collection were made with a Birge Ekman grab with a substrata coverage of 0.0225 $m^2$. The macrofauna were separated by using 0.5 mm. seive. The organisms were preserved in 5% formalin, sorted, counted and identified in the laboratory.

## RESULTS

## MACROBENTHOS IN SEASONAL FIELD

Polychaetes, Crustaceans, Molluscs and fishes were the benthic organisms obtained from the seasonal field. An analysis of the numerical abundance of various organisms showed that 57.63% were crustaceans 28.06% polychaetes, 14.1% molluscs and 0.19% fishes. Among crustacea the dominent groups were amphipods and tanaids. Amphipods were represented by only two species, *Eriopisa chilkensis* and *Melita zeylanica*. But *E. chilkensis* was the dominent species whereas *M. zeylanica* was poorly represented. Tanaids were represented by Apseudus gymnophobia and A. Chilkensis Though A. chilkensis were well represented throughout the season A. gymnophobia were numerically more abundant. Prawns were very rarely caught and included M. dobsoni. Polychaetes were represented by three species but Dendronereis estuarina was the most dominant species. Other species of polychaete included Prionospio pinnata and P. polybranchiata. Molluscs were represented by Villorita sp. Fishes were found only in a very few samples and was represented by Glossogobius sp.

An examination of the numerical abundance of various organisms shows that polychaetes and amphipode increased in number with the season (Table XII & XIII) But maximum number of tanaids were seen in October and November and their number decreased in later months. Molluscs were maximum during the month of February. Yearly variation of the number of organisms were also negligible.

PERENNIAL FIELD

As in seasonal field the faunal taxa in perennial field included polychaetes, crustaceans, molluscs and fishes. Out of these 63.6% were crustaceans, 28.48% polychaetes, 7.83% molluscs and the rest fishes. The crustacean fauna was composed of amphipods, tanaids and decapods. Amphipods were represented by only E. chilkensis and M. zeylanica. E. chilkensis was the dominant species which constituted about 87% of amphipods. The decapods included prawns which were obtained only occassionally. Among tanaids A. gymnophobia formed about 81% and the rest was A. chilkensis. Polychaetes were represented by five species namely D. estuarina, P. pinnata, P. polybranchiata, Nephthys polybranchiata and Lycastis indica. An analysis of the numerical abundance of polychaetes showed that 75% were D.estuarina 21% P. pinnata, 1.6% P. polybranchiata, 1.3% N. polybranchiata and the rest L. indica. Molluscs were dominated by Villoritta sp. though cardium sp. was also obtained occasionally.

An analysis of the numerical abundance of various organisms in various stations indicated that polychaetes, tanaids, amphipods and molluscs were present in varying quantities throughout the season (Table XIV & XV) Polychaetes showed an increase during the premonsoon period. During the monsoon and post-monsoon periods their number decreased. Amphipods were abundant during the months of April, May, June and November and were less on other periods. The population of tanaids were high in all the months except October-December. Maximum number of tanaids were obtained during September. In the case of molluscs maximum number were noticed during May.

## DISCUSSION

In the seasonal field polychaetes, amphipods and tanaids were obtained from all stations throughout the season. In these organisms one each species was dominent in every group, which constituted more than 75% of the total number of organisms in a group. Other species were either sparesely distributed and rate. When amphipods, polychaetes and molluscs showed an increasing trend as the prawn filtering season progressed, the number of tanaids decreased. These fluctuations in the numerical abundance of organisms can be explained only by understanding the environmental characteristics of the seasonal field. As stated elsewhere, salinity can be deemed as the most important ecological parameter that control the abundance of the animal communities in the seasonal field. In the seasonal field prawn culture started in the premonsoon period where the system is fresh water dominated. With the commencement of culture operations salinity also started recovering thus reaching its maximum in April. Hence it can be assumed that postmonsoon is a transition period from fresh water to saline conditions in the seasonal field. This is a transition period for the benthic organisms also. Fresh water forms start declining and recruitment of brackish water forms begins. With the establishment of high salinity the benthic biomas of saline forms also reaches its maximum.

In the perennial field also the various animal groups represented were same as that in the seasonal field. But the species diversity of polychaetes were more when compared to the seasonal field. Among polychaetes D. estuarina and P. pinnata were of common occurrence whereas other species were rare.

The hydrographic conditions underwent rapid seasonal changes. As in the seasonal fields, culture started in the perennial field in October when the salinity was zero. November onwards salinity started increasing attaining the maximum in April. With the onset of south-west monsoon in May salinity decreased resulting in fresh water conditions in August and this condition prevailed till October. With this change in season the organisms also fluctuated both in abundance and diversity. Polychaetes showed a marked decrease during south-west monsoon and the number increased in pre-monsoon period. This may be because of the recruitment of some species after the south-west monsoon. Poor biomass during the monsoon has been observed by several workers. (Desai and Krishnankutty, 1967; Kurian, 1972; Harkantra, 1975). According to Jones (1950), the significant factors which may influence the distribution of bottom fauna are temperature, salinity and nature of bottom deposit. Several other investigators have reported reduction in the benthos as a result of the combination of reduced salinity, physical scouring of the estuary and reduced oxygen levels, (Stephenson *et al.* 1977; Stephenson *et al.* 1979; Rosenberg 1977; Boesch *et al.* 1976). In the present study it is found that the oxygen values are low both in the seasonal and perennial fields. This reduced oxygen level may have some influence on restricting the species abundance and diversity in these filtering fields. But temperature may not have any effect as very high or low temperatures are not found occurring in these fields. It is reported by various workers that the abundance and distribution of benthic fauna is related to sediment type. Ansari *et al.* (1977) found that polychaetes preferred muddy sand and were totally absent in the clayey deposits. Harkantra (1982) observed that the very coarse sand and the very fine fraction sediment have a low benthic biomass whereas medium grain size has a rich fauna. Savich (1972) is of the opinion that the distribution of amphipods depends on the availability of organic matter in the substratum. Another important factor that control the benthic population is predation. The benthos form the most important food of prawns. Benthic crustacea is its well nourished food. According to Balasubramaniam *et al.* (1979) *A. chilkensis* was preferred by *M. dobsoni* whereas it has always avoided *A. gymnophobia*. The abundance of *A. gymnophobia* in both the perennial field and seasonal field and a comparatively less number of A. chilkensis may be explained as due to this selective feeding.

The average number of macrofauna recorded from the seasonal field is 1248 per $m^2$ and 2145 per $m^2$ from the perennial field. The perennial field was found more productive than the seasonal field. Thieneman (1925) has classified a lake bed producing 1000 animals or less per $m^2$ as oligotraphic, one producing above 2000 per $m^2$ as eutrophic and one between 1000 and 2000 as mestrophic. Based on this classification the seasonal field can be considered as mesotrophic and perennial field as eutrophic. No data in numerical abundance of benthic fauna is available to compare the present observation. But Pillai (1978) has recorded an average macrofauna of $2332/m^2$ from Cochin backwaters. Based on the primary productivity, Gopinathan et. al. (1982) have reported the region under investigation as moderately productive. The primary productivity is dependent on nutrient supply. Thus the fertility of the overlying water influences the benthic productivity because a good share of the plankton produced sink to the bottom which form the food of benthic organisms.

Based on the average numerical abundance of the fields it can be qualified as productive. But in the matter of species diversity both the fields were very poor. The health of an aquatic ecosystem cannot be assessed based on numerical abundance of organisms because even in polluted waters the resistant varieties are abundant. It is generally agreed fact that the greater the diversity of the aquatic life, the greater the structural and functional stability of the system and therefore the greater the health of the system. Based on this it can be argued that the health of the ecosystem both in the perennial and seasonal fields are not appreciable. A comparison of the numerical abundance of benthic fauna in these fields and in the adjoining backwaters also proves the poverty of the species diversity. Gopalakrishnan (1978) has reported 32 species of polychaetes, 9 species of crustacea, 19 species of molluscs and 4 species of fishes in the benthic collections from Cochin backwaters. He has also reported sipunculoids, echiuroids and echinodermata among the bottom fauna. The reason why these fields support only a limited number of organisms is not known. But in this area coconut husk retting is a regular practice. Effluents discharged from various factories may also be reaching these fields along with the tidal flow. In the absence of concrete evidence of the nature of pollutants that may be having adverse effect on this ecosystem, it is possible only to suggest that appropriate steps are to be taken for the proper management of these prawn filtering fields.

TABLE XII

NUMERICAL ABUNDANCE OF BENTHIC ORGANISMS IN SEASONAL FIELD
(1980-81)

| Sl. No. | Organisms | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. |
|---|---|---|---|---|---|---|---|---|
| 1. | Polychaeta | 13 | 19 | 22 | 32 | 44 | 41 | 52 |
| 2. | Amphipoda | 11 | 13 | 23 | 13 | 32 | 35 | 39 |
| 3. | Tanaidacea | 61 | 60 | 34 | 23 | 41 | 37 | 31 |
| 4. | Mollusca | 3 | 5 | 24 | 5 | 55 | 30 | 12 |
| 5. | Prawns | -- | 1 | -- | 2 | 1 | 1 | -- |
| 6. | Fishes | -- | -- | -- | 1 | -- | -- | -- |

TABLE XIII

NUMERICAL ABUNDANCE OF BENTHIC ORGANISMS IN SEASONAL FIELD
(1981-82)

| Sl. No. | Organisms | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. |
|---|---|---|---|---|---|---|---|---|
| 1. | Polychaeta | 15 | 17 | 25 | 22 | 50 | 41 | 50 |
| 2. | Amphipoda | 38 | 26 | 21 | 36 | 34 | 24 | 29 |
| 3. | Tanaidacea | 57 | 55 | 30 | 28 | 29 | 24 | 34 |
| 4. | Mollusca | 4 | 15 | 10 | -- | 54 | 13 | 1 |
| 5. | Prawns | -- | -- | -- | 1 | -- | 1 | 1 |

NUMERICAL ABUNDANCE OF BENTHIC ORGANISMS IN PERENNIAL FIELD (1980-81)

| Sl. No. | Organisms | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Polychaeta | 91 | 81 | 95 | 86 | 116 | 93 | 166 | 216 | 97 | 65 | 70 | 65 |
| 2. | Amphipoda | 48 | 85 | 62 | 83 | 71 | 121 | 116 | 167 | 115 | 61 | 36 | 105 |
| 3. | Tanaidacea | 92 | 57 | 89 | 175 | 256 | 167 | 266 | 161 | 160 | 63 | 137 | 357 |
| 4. | Mollusca | 19 | 13 | -- | 45 | 59 | 25 | 4 | 112 | 28 | 63 | 1 | 8 |
| 5. | Prawns | 3 | -- | 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6. | Fish | 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 | -- |

TABLE XV

NUMERICAL ABUNDANCE OF BENTHIC ORGANISMS IN PERENNIAL FIELD (1981-82)

| Sl. No. | Organism | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Polychaeta | 77 | 59 | 87 | 87 | 193 | 209 | 229 | 202 | 77 | 52 | 66 | 60 |
| 2. | Amphipoda | 84 | 120 | 97 | 99 | 68 | 84 | 106 | 153 | 126 | 74 | 58 | 77 |
| 3. | Tanaidacea | 169 | 63 | 98 | 101 | 97 | 127 | 171 | 137 | 94 | 101 | 253 | 282 |
| 4. | Mollusca | 37 | 9 | 15 | 38 | 75 | 6 | 14 | 117 | 9 | 11 | 10 | 9 |
| 5. | Prawns | 1 | -- | 1 | -- | 1 | -- | 1 | -- | -- | -- | 1 | -- |
| 6. | Fish | 1 | -- | 2 | -- | -- | -- | -- | -- | -- | 1 | -- | -- |

## CHAPTER XII

## FOOD AND FEEDING HABITS OF P.INDICUS IN CULTURE FIELDS

### INTRODUCTION

Investigations on the food and feeding habits of penaeid prawns has assumed much importance in recent years. This is mainly because of the keen interest shown by a number of maritime countries to culture commercially important species of prawns. An understanding of the food habits, food preference and mechanism of feeding is essential for the successful culture of prawns.

Detailed investigations are made by various workers on the stomach contents of different species of prawns. Williams (1955) made some studies on food of *P. setiferus*, *P. aztecus* and *P. duorarum*. Hall (1962) investigated the food of prawns in the culture ponds in Singapore and Dall (1967) studied some Australian species. Studies on stomach contents of penaeid prawns of India are conducted by Menon (1952), Gopalakrishnan (1952), Kuttyamma (1973), Thomas (1972, 1980) and George (1974). All these investigators have analysed the gut contents of various species of prawns caught from their natural habitat. Studies on the food of prawns from culture ponds/fields are lacking. Perhaps the only account may be that of Das *et al.* (1982) on prawns in the brackishwater culture ponds of Sunderbans. But so far no comparative data is available on the food habits of prawns in seasonal and perennial fields. Similarly no attempt is made so far to relate the food habits with the abundance of various benthic organisms in such prawn culture fields. In the present study the stomach contents of P. indicus collected from seasonal and perennial fields are analysed and compared. Attempt is also made to explain the availability of benthic organisms in the stomach in relation to their abundance in the culture fields.

## MATERIALS AND METHODS

### Stomach contents

P. Indicus were collected every month from a seasonal field and perennial field during night. 105 specimens of length 80 mm. to 125 mm. were collected from the seasonal field and 180 specimens with a length of 75 mm. to 140 mm. from perennial field were used for the stomach analysis. Collections were made during different periods of the night. The specimens were preserved in formalin soon after collection and were taken to the laboratory for food analysis. The stomach contents were analysed by the 'points method' (Swynnerton and Worthington, 1940).

### Feeding habit

Three P. indicus (length 9-10 cms.) were kept in a 10 litre glass trough. The trough was provided with a substratum of 3 cm. thickness with mud collected from filtering field. Amphipods, tanaids and polychaetes were introduced to the substratum prior to the introduction of prawns. The salinity of the water was 22 ± 1 ‰.

## RESULTS

### Stomach content analysis

Analysis of the stomach contents of *P. indicus* from seasonal field showed 37.17% of diatoms, 27.89% of animal matter, 25.14% plant matter along with sand and mud and some miscellaneous substances (Table XVI & XVII) Maximum animal matter (45.57%) was found in the month of April and minimum (9.39%) in October. In the case of diatoms, maximum was found in October while the plant matter showed its peak in March.

In the perennial field the proportion of the food items were as follows: animal matter 33.64%, diatoms 29.4%, plant matter 27.21% followed by some unidentified miscellaneous items and sand and mud. Maximum animal matter was found during the premonsoon period while its percentage decreased during other seasons. Highest percentage of diatoms were observed in January while the plant matter registered its peak in November.

The diatoms were represented by *Fragilaria* sp; *Rhizosolenia* sp., *Coscinodiscus* sp., *Navicula* sp., and *Synedra* sp., Plant matter included algal fragments and bits of aquatic macrophyte larves. Crustaceans were represented by amphipods, tanaids and decapods.

Feeding habit

*P. indicus* caught its prey while slowly moving over the substrata. Chelipods are used to search the food and grasp it. Once the prawns came across with a prey moving over the substratum, the response was immediate.

## DISCUSSION

A perusal of the works of various investigators on the stomach contents of *P. indicus* shows that they all differ considerably on the food item in the stomach of this species. This is obviously because the specimens were collected from different sources where the available food may also differ considerably. Gopalakrishnan (1952) reported that vegetable matters and crustaceans like copepods, ostracods and amphipods formed the bulk of the food consumed by *P. indicus*. He has also found molluscan shells, polychaete worms, echinoderm larvae, hydroids and trematods in the stomach contents. According to Hall (1962) large specimens of *P. indicus* feeds mainly on large crustaceans while the 'small' prawns sustains on plant tissue. Kuttyamma (1973) found a high percentage of debris (50.7%) followed by plant matter (25.0%) and animal matter (22.0%) in the stomach of *P. indicus* collected from Cochin area. Das *et al.* (1982) reported diatoms as the major food item of *P. indicus* from the brackish water culture ponds of Sunderbans. But none of the above workers have made an attempt to relate the benthic availability of prey organisms with the stomach contents. The time of collection of specimens is also an important factor which decides the presence of food materials in the stomach.

In the present investigation also it is found that *P. indicus* is an omnivore and a detritus feeder. But the stomach contents of the specimens collected from the seasonal field and perennial field showed difference. In the seasonal field if diatoms were the major food item, in the perennial field animal matter were the major food item. Plant matter was almost same both in the seasonal field and perennial field specimens. This can be explained as a result of the variation in the availability of food organisms in the two field. As explained in the Chapter on benthos the numerical abundance of benthic organisms are almost double per $m^2$ of area in the perennial field than the seasonal field. Thus more animal matter is available to the prawn in the perennial field. But the reason for not having a proportionate increase of animal matter in the stomach contents may be because of the variation in the population density of prawns in the fields, nature of substratum etc. In both the fields more number of benthic fauna is found during the pre-monsoon months. With the increase in the numerical abundance of benthic organisms an increase in the percentage of animal matter is also found in the gut contents. As the benthic fauna increases there is a reduction in the density of prawns in the field because these are months of active prawn filtration thus making more animal food available to the prawns in the field. The present observation of high percentage of animal matter in the stomach is in consistent with the observarions of Hall (1962). The diatoms and plant matter are digested when the prawn browse on the epi-flora and epi-fauna. The observations of Hall (1962), Caces-Borja and Rasalam (1968) and Das et al. (1982) suggests that the prawns feed actively on the diatoms and blue-green algae which are found in algal mats of prawn ponds. Kuttyamma (1973) has reported plenty of algal fragments in the stomach during August and October.

The seasonal variations in the stomach contents show that this species has a capacity to thrive on a variety of food items. But high incidence of animal matter in the stomach of the prawns from the perennial field shows that the prawn may have more affinity for animal food. Maximum food was observed in the stomach of prawns caught in the early morning. This shows their nocturnal habit.

As in other decapods, the dactyles seems to be the sites of contact chemoreception. The benthic organisms are located while walking over them. In the laboratory it is seen that the disturbance caused to the substratum with the perepods sometimes caused the organisms to come to the surface of the substratum. These organisms were immediately caught by the prawn. Lalithambika Devi _et al_. (1980) have reported that high concentrations of silt and clay in the substrata adversely affect the preying efficiency of _P. indicus_

In a number of instances when _P. indicus_ were fed individually with a mixture of amphipods like _M. zeylanica_, _E. chilkensis_ and _D. estuarina_, the prawns were found feeding actively on the polychaete followed by the large amphipod, _M. zeylanica_. The small _E. chilkensis_ were caught last. But when these organisms were supplied separately they were caught immediately. This shows that the prawn shows a preference for large organisms and slow moving animals.

Similarly when clam meat and live amphipods were introduced to the culture tank, it always showed a preference for the live organisms. Balasubramaniam *et al*. (1979) have reported that *M. dobsoni* always avoided the tanaid *A. gymnophobia*. But *P. indicus* was found eating any benthic organisms it caught while searching for food.

TABLE XVI

PERCENTAGE COMPOSITION OF FOOD OF P. INDICUS IN PERENNIAL FIELD 1980-81

| Food item | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diatoms | 32.12 | 24.31 | 18.26 | 42.70 | 21.70 | 14.79 | 20.17 | 38.63 | 28.24 | 34.52 | 40.27 | 36.10 |
| Plant matter | 39.60 | 45.93 | 32.43 | 12.40 | 27.68 | 26.18 | 18.46 | 11.41 | 24.38 | 29.16 | 32.76 | 24.42 |
| Crustacea | 12.42 | 16.78 | 30.18 | 26.70 | 34.79 | 37.41 | 34.71 | 26.18 | 20.13 | 13.25 | 16.19 | 20.18 |
| Polychaeta | 3.18 | 2.63 | 4.40 | 6.18 | 5.18 | 7.18 | 11.18 | 12.43 | 9.69 | 5.29 | 2.96 | 4.88 |
| Mollusca | 0.93 | 1.70 | 2.17 | 3.78 | 1.63 | 2.69 | 2.15 | 6.17 | 5.63 | 6.38 | 1.36 | 2.79 |
| Sand and mud | 6.37 | 4.80 | 8.17 | 5.31 | 4.37 | 5.37 | 4.98 | 2.18 | 7.57 | 6.17 | 3.13 | 4.45 |
| Miscellaneous | 5.38 | 3.85 | 4.39 | 2.93 | 4.65 | 6.38 | 8.35 | 3.00 | 4.36 | 5.23 | 3.33 | 7.18 |

TABLE XVII

PERCENTAGE COMPOSITION OF FOOD OF P. INDICUS IN SEASONAL FIELD 1980-81

| Food item | October | November | December | January | February | March | April |
|---|---|---|---|---|---|---|---|
| Diatoms | 53.81 | 47.80 | 51.66 | 37.22 | 33.53 | 17.67 | 18.51 |
| Plant matter | 25.20 | 34.68 | 16.13 | 21.33 | 26.49 | 31.60 | 20.60 |
| Crustacea | 10.00 | 8.16 | 18.18 | 26.86 | 18.97 | 23.43 | 31.43 |
| Polychaeta | -- | 1.40 | 3.64 | 5.31 | 9.48 | 11.18 | 12.49 |
| Mollusca | -- | 0.83 | 1.70 | -- | 6.34 | 4.27 | 1.65 |
| Sand and mud | 8.35 | 5.18 | 3.48 | 2.53 | 3.32 | 6.48 | 9.18 |
| Miscellaneous | 2.64 | 1.95 | 5.21 | 6.75 | 1.87 | 5.37 | 6.14 |

## CHAPTER XIII

## LENGTH WEIGHT RELATIONSHIP AND CONDITION FACTOR OF PENAEUS INDICUS

### INTRODUCTION

In crustacea growth is by periodic shedding of the exoskeleton. According to Carlisle and Dohrn (1953), there are four stages of growth in crustaceans: 1) proecdysis, the stage preceding ecdysis, 2) ecdysis, the actual process of shedding the old shell 3) metecdysis, the stage after ecdysis, during which period the new shell is hardened and the animal returns to normal condition and 4) intermolt. In the present work growth was studied using length weight measurements of *P. indicus* from a seasonal field and a perennial field. The length weight relation and condition factor will enable a comparison of the values and to assess the suitability of the area for culture of prawns.

### MATERIALS AND METHODS

*P. indicus* were collected monthly for two seasons from a seasonal field and a perennial field. The length of the specimen were measured from the tip of the rostrum to the tip of the telson. The weight was taken with a sensitive balance.

<u>Length weight relationship</u>

The data of length weight relationships were statistically analysed. The mathematical model of the length weight relationship fitted is $w = al^b$ where <u>w</u> represents weight in gms. and <u>l</u> represents length in mm. The model was fitted by using the method of least squares. For this, first the logaritham of the length weight relation is taken.

$$\log w = \log a + b \log l$$

let $\log w = W$, $\log a = A$ and $\log l = L$

∴ the above equation becomes

$$W = A + b L$$

Fitting this straight line to the data by the method of least square, the following normal equations are obtained.

$$b \sum l^2 + A \sum L = \sum LW \text{ ......(1)}$$

$$b \sum L + NA = \sum W \text{ ......(2)}$$

From eq. (1) and (2) b and A can be solved. Antilog of A will give <u>a</u>. This value of '<u>a</u>' and '<u>b</u>' are substituted in the equation.

$$w = al^b$$

These equations are shown in tables XVIII to XXI.

## TABLE XVIII

LENGTH WEIGHT RELATIONSHIP OF P. INDICUS (SEASONAL FIELD) 1980 - 81

| | |
|---|---|
| December 1980 | $w = 0.00447\ 1^{3.1436}$ |
| January 1981 | $w = 0.08085\ 1^{1.9479}$ |
| February 1981 | $w = 0.02185\ 1^{2.5628}$ |
| March 1981 | $w = 0.01101\ 1^{2.8263}$ |
| April 1981 | $w = 0.00770\ 1^{2.9723}$ |

## TABLE XIX

LENGTH WEIGHT RELATIONSHIP OF P. INDICUS (SEASONAL FIELD) 1981 - 82

| | |
|---|---|
| January 1982 | $w = 0.0000001094\ 1^{3.8645}$ |
| February 1982 | $w = 0.000001288\ 1^{3.3523}$ |
| March 1982 | $w = 0.0000002431\ 1^{3.6934}$ |
| April 1982 | $w = 0.000003332\ 1^{3.1559}$ |

## TABLE XX

LENGTH WEIGHT RELATIONSHIP OF P. INDICUS (PERENNIAL FIELD) 1980 - 81

| | |
|---|---|
| December 1980 | $w = 0.01575\ 1^{2.5099}$ |
| January 1981 | $w = 0.0006896\ 1^{3.9884}$ |
| February 1981 | $w = 0.0009947\ 1^{3.7831}$ |
| March 1981 | $w = 0.02802\ 1^{2.4682}$ |
| April 1981 | $w = 0.002153\ 1^{3.4632}$ |
| May 1981 | $w = 0.004083\ 1^{3.2076}$ |
| June 1981 | $w = 0.002850\ 1^{3.3521}$ |
| July 1981 | $w = 0.003245\ 1^{3.3146}$ |

August 1981 $w = 0.002321\ l^{3.4403}$

September 1981 $w = 0.01167\ l^{2.8023}$

TABLE XXI

LENGTH WEIGHT RELATIONSHIP OF *P. INDICUS* (PERENNIAL FIELD) 1981 - 82.

| | |
|---|---|
| January 1982 | $w = 0.001484\ l^{3.6069}$ |
| February 1982 | $w = 0.02208\ l^{2.5647}$ |
| March 1982 | $w = 0.01280\ l^{2.7739}$ |
| April 1982 | $w = 0.003360\ l^{3.3010}$ |
| May 1982 | $w = 0.004544\ l^{3.1684}$ |
| June 1982 | $w = 0.001392\ l^{3.6301}$ |
| July 1982 | $w = 0.005825\ l^{3.2431}$ |

The goodness of fit of the logarithmic straight lines worked for all the equations cited above were tested with the help of coefficient of correlation between log weight and log length. The coefficient of correlations, the A, b, the number of observations and the level of significance, for *P. indicus* in seasonal f'eld are shown in Table XXII & XXIII and that in perennial field in Table XXIV & XXV.

TABLE XXII

COEFFICIENT OF CORRELATION THE A, b, THE NUMBER OF OBSERVATIONS AND THE LEVEL OF SIGNIFICANCE FOR P. INDICUS IN SEASONAL FIELD - 1980-81.

| Month | r | b | A | n | significance level |
|---|---|---|---|---|---|
| Dec. 1980 | 0.9920 | 3.1436 | -2.3497 | 37 | $P < 0.001$ |
| Jan. 1981 | 0.9226 | 1.9479 | -1.0923 | 227 | $P < 0.001$ |
| Feb. 1981 | 0.8400 | 2.5628 | -1.6606 | 335 | $P < 0.001$ |
| March 1981 | 0.9762 | 2.8263 | -1.9582 | 443 | $P < 0.001$ |
| April 1981 | 0.09563 | 2.9723 | -2.1134 | 327 | $P < 0.001$ |

TABLE XXIII

COEFFICIENT OF CORRELATION THE A, b, THE NUMBER OF OBSERVATIONS AND THE LEVEL OF SIGNIFICANCE FOR P. INDICUS IN SEASONAL FIELD 1981-82.

| Month | r | b | A | n | Significance level |
|---|---|---|---|---|---|
| January 82 | 0.9915 | 3.8645 | -6.9610 | 215 | $P < 0.001$ |
| Feb. '82 | 0.9883 | 3.3523 | -5.8901 | 188 | $P < 0.001$ |
| March '82 | 0.9873 | 3.6934 | -6.6142 | 197 | $P < 0.001$ |
| April '82 | 0.9880 | 3.1559 | -5.4774 | 175 | $P < 0.001$ |

TABLE XXIV

COEFFICIENT OF CORRELATION, THE A, b, THE NUMBER OF OBSERVATIONS AND THE LEVEL OF SIGNIFICANCE FOR P. INDICUS IN PERENNIAL FIELD 1980-81.

| Month | r | b | A | n | Significance level |
|---|---|---|---|---|---|
| Dec. '80 | 0.9709 | 2.5099 | -1.8027 | 214 | P < 0.001 |
| Jan. '81 | 0.9884 | 3.9401 | -3.1614 | 403 | P < 0.001 |
| Feb. '81 | 0.9554 | 3.7831 | -3.0023 | 326 | P < 0.001 |
| Mar. '81 | 0.9026 | 2.4682 | -1.5525 | 504 | P < 0.001 |
| Apr. '81 | 0.9843 | 3.4632 | -2.6669 | 378 | P < 0.001 |
| May '81 | 0.9716 | 3.2076 | -2.3891 | 259 | P < 0.001 |
| June '81 | 0.9736 | 3.3521 | -2.5435 | 334 | P < 0.001 |
| July '81 | 0.9241 | 3.3146 | -2.4887 | 457 | P < 0.001 |
| Aug. '81 | 0.9924 | 3.4403 | -2.6342 | 230 | P < 0.001 |
| Sept. '81 | 0.8840 | 2.8023 | -1.9329 | 178 | P < 0.001 |

TABLE XXV

COEFFICIENT OF CORRELATION, THE A, b, THE NUMBER OF OBSERVATIONS AND THE LEVEL OF SIGNIFICANCE FOR P. INDICUS IN PERENNIAL FIELD 1981-82.

| Month | r | b | A | n | Significance level |
|---|---|---|---|---|---|
| Jan. '82 | 0.9908 | 3.6069 | -2.8286 | 185 | P < 0.001 |
| Feb. '82 | 0.8252 | 2.5647 | -1.6551 | 215 | P < 0.001 |
| Mar. '82 | 0.9496 | 2.7739 | -1.8928 | 158 | P < 0.001 |
| April '82 | 0.9844 | 3.3010 | -2.4749 | 109 | P < 0.001 |
| May '82 | 0.8998 | 3.1684 | -2.3425 | 126 | P < 0.001 |
| June '82 | 0.8951 | 3.6301 | -2.8565 | 110 | P < 0.001 |
| July '82 | 0.9636 | 3.2431 | -2.4173 | 124 | P < 0.001 |

## Condition factor

The condition factors were worked out for monthly observations, in order to know the monthwise fluctuations of the animals. Fultons method (Ricker 1975) of finding the condition factor was employed using $k = w/l^3$. k was calculated separately for every month and is presented in Tables XXVI & XXIX. The k values thus obtained were compared with a values.

TABLE XXVI

CONDITION FACTOR k FOR P. INDICUS IN SEASONAL FIELD 1980-81

| Month | k |
|---|---|
| December 1980 | 0.006126 |
| January 1981 | 0.006436 |
| February 1981 | 0.007036 |
| March 1981 | 0.007171 |

TABLE XXVII

CONDITION FACTOR k FOR P. INDICUS IN SEASONAL FIELD 1981 - 82.

| Month | k |
|---|---|
| January 1982 | 0.000006230 |
| February 1982 | 0.000006901 |
| March 1982 | 0.000006965 |
| April 1982 | 0.000007119 |

TABLE XXVIII

CONDITION FACTOR k FOR P. INDICUS IN PERENNIAL FIELD
1980 - 1981

| Month | k |
|---|---|
| December 1980 | 0.006219 |
| January 1981 | 0.006176 |
| February 1981 | 0.006708 |
| March 1981 | 0.007038 |
| April 1981 | 0.006939 |
| May 1981 | 0.008572 |
| June 1981 | 0.007600 |
| July 1981 | 0.007448 |
| August 1981 | 0.007189 |
| September 1981 | 0.007001 |

TABLE XXIX

CONDITION FACTOR k FOR P. INDICUS IN PERENNIAL FIELD
1981 - 1982

| Month | k |
|---|---|
| January 1982 | 0.006067 |
| February 1982 | 0.007081 |
| March 1982 | 0.007161 |
| April 1982 | 0.006700 |
| May 1982 | 0.006852 |
| June 1982 | 0.007323 |
| July 1982 | 0.007134 |

## RESULTS AND DISCUSSION

### Length weight relationship

From the tables it is seen that the coefficient of correlation between log weight and log length are highly significant ($P < 0.001$). This indicates that there exists a linear relationship between log weight and log length and correspondingly the length weight relationships fitted for the data are fitting the date closely.

When the exponent of 1 is 3, the growth can be interpreted as isometric and when it is less than or more than 3 it can be interpreted as allometric growth. In the case of *P. indicus*, in both fields, during most of the months under observation, the growth rate is near to isometric and during other times it is allometric. In the perennial field in both the years, maximum fluctuation of the value from 3 was seen in January. Least fluctuations were found in May. The value fluctuated both sides. In seasonal field also maximum fluctuation was seen in January. But in 1980-81 all values were less than 3 except in December while in 1982 all values were more than 3 indicating much yearly fluctuation in the growth pattern. The difference in growth between the fields and in the same field between the months may be because of the environmental conditions and availability of food. According to Lalithambika Devi *et al.* (in press) the small difference observed between the values of the length weight exponents may be expected, since in nature extraneous variations are bound to occur.

Condition factor

Fulton's condition factor is suitable for comparing different individual fish of the same species. It will also indicate the differences related to sex, season or place of capture. It is most useful, if under average or standard conditions, the exponent b is actually equal to 3 for the species in question. Fultons factor can also be used to compare fish of approximately the same length, no matter what the value of b is.

The heavier a fish at a given length, the larger the factor and (by implication) the better 'condition' it is in. A comparison of the k values with a values in the case of *P. indicus* shows that during most of the months the prawns are in better condition. But during December and March 1980-81 and February and March 1982 the k values were less than a. This indicates that the prawns were in poor condition during these months. In the seasonal field a comparison of k values with a values shows that the prawns were in poor condition during most of the months in 1980-81. But the conditions were better during all the months in 1982.

Investigations on the benthic production of the seasonal and perennial fields showed that the perennial fields were more productive than seasonal fields. Thus the prawns in the perennial field had more food. But the species diversity of benthic organisms indicates that the environmental conditions are not well suited for culture. This lack of diversity of food organisms has a harmful effect both on the growth and condition of the prawn. Nair *et al.* (1982) reported that when *P. indicus* were fed by live earthworm alone at difference levels of feeding it significantly affected their growth but the condition factor remained surprisingly constant. This also shows that the quality of food is reflected on the ponderal index.

## CHAPTER XIV

## SUMMARY

Prawn culture is practiced in Kerala in two types of fields namely seasonal and perennial. In seasonal fields paddy is grown during the monsoon period and prawns are cultured during the rest of the year. When compared to seasonal fields, perennial fields are subjected to much fluctuations in its environmental characteristics.

The perennial fields were found more productive than seasonal fields. The benthic production in perrenial fields were almost double that of seasonal fields. But in the matter of species diversity both fields were equal. Seasonal changes were observed in the species abundance of benthic organisms in both the seasonal and perennial fields.

*P. indicus* is an omnivore and a detritus feeder. The stomach contents of the prawns caught from the seasonal field and perennial fields were found different. *P. indicus* showed preference for slow moving and large organisms. Similarly more preference was shown for live food. The dactyls seems to be the sites of chemoreception.

Both isometric and allometric growth were noticed in *P. indicus*. But during most of the months

the growth was near to isometric. The condition of the prawn also fluctuated between better and poor. During most of the months the prawn in perennial fields were in good condition while in the seasonal fields the condition changed from year to year. This indicates that the perennial field provides a better habitat for *P. indicus*.

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## EXPLANATION TO PHOTOGRAPHS

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| Photograph I | Long line and bait |
| Photograph II | Scoop net |
| Photograph III | Square type crab net |
| Photograph IV | Round type crab net |

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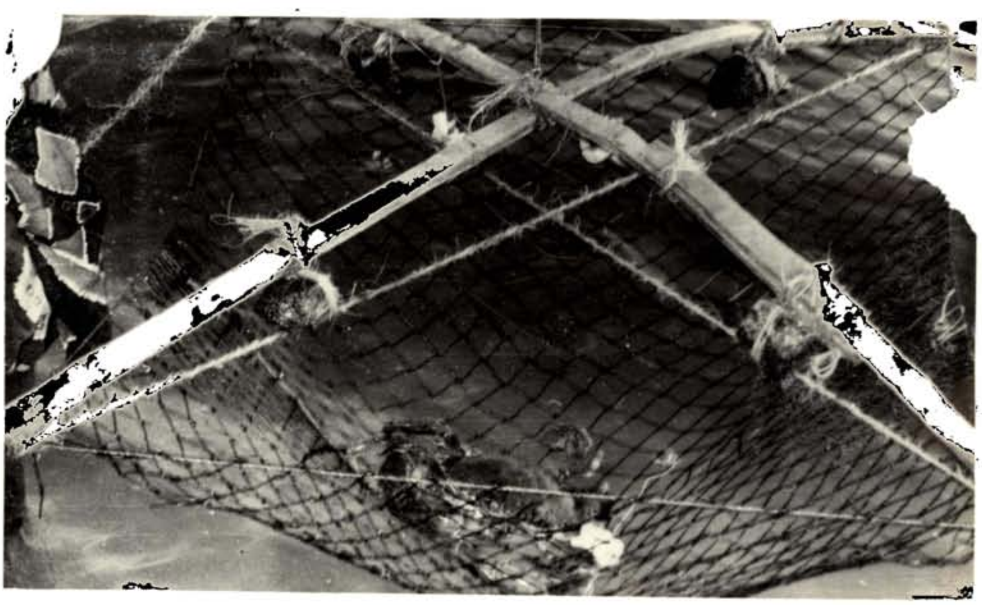
PHOTOGRAPH I

PHOTOGRAPH II

PHOTOGRAPH III



PHOTOGRAPH IV