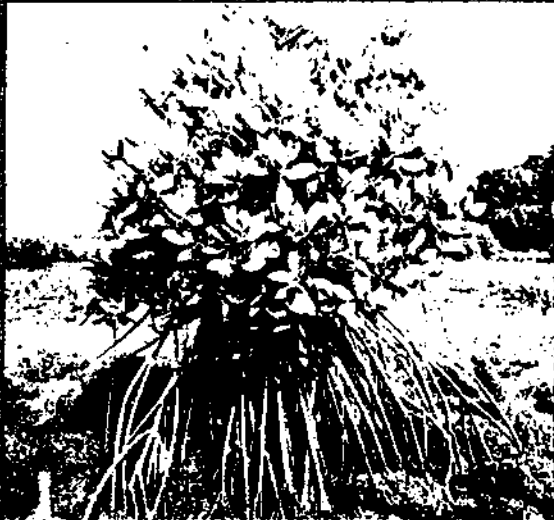




ANNUAL REPORT

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**NATIONAL INSTITUTE OF
OCEANOGRAPHY**

(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)
DONA PAULA, GOA 403 004, INDIA.

COVER PAGE : MANGROVE VEGETATION

Top left : Mangrove forest dominated
by **Rhizophora Mucronata**

Top right : Oyster bed below
the mangrove
plant — **Rhizophora**

Bottom left: Flowering in
Sonneratia alba

Bottom right: Flowering in
Avicennia officinalis

ANNUAL REPORT

20



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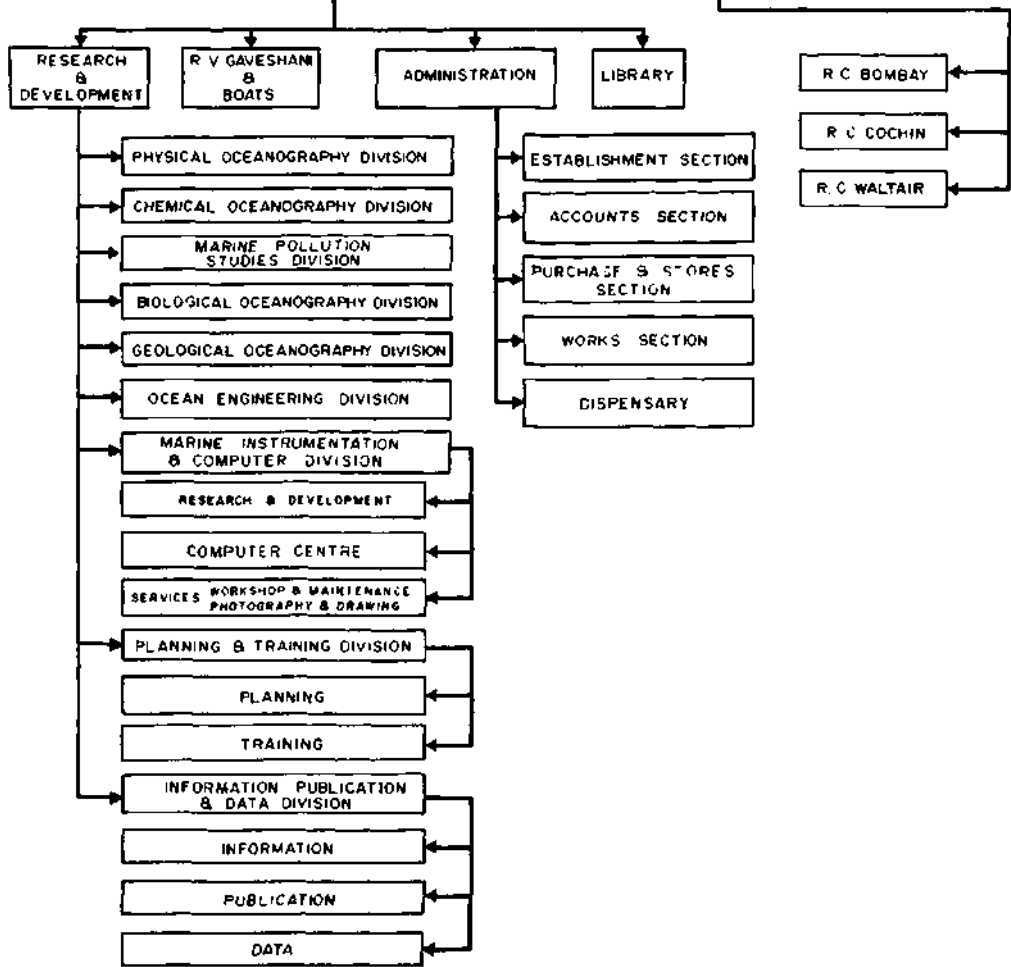
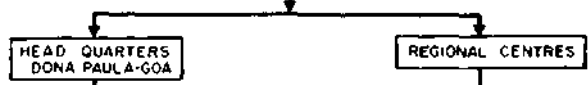
Dr. B.N. Desai,
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ORGANISATIONAL CHART

NATIONAL INSTITUTE OF OCEANOGRAPHY
(Council of Scientific and Industrial Research)



सारांश —

यह राष्ट्रीय समृद्ध-विज्ञान संस्थान की २० वीं वार्षिक - रिपोर्ट है। जैसा कि पिछले वर्षों में किया जाता था उसकी जगह १९८४ की तिथि वर्ष रिपोर्ट के स्थान पर यह १९८४-८५ की वित्तीय वर्ष रिपोर्ट है। ऐसा सी एस आइ आर. की वार्षिक रिपोर्ट की पद्धति हेतु किया गया है। चूंकि पिछली वार्षिक रिपोर्ट दिसम्बर १९८३ तक के लिये थी, इस रिपोर्ट में जनवरी १९८४ से मार्च १९८५ तक के कार्यों को सम्मिलित किया गया है।

हमारी प्रधानमन्त्री श्रीमती इन्दिरा गान्धी जो कि सी.एस.आइ.आर. की अध्यक्ष भी थीं, की अप्राकृतिक मृत्यु को हम यहाँ पर बहुत दुःख के साथ रिकार्ड कर रहे हैं। श्रीमती गांधी न केवल एक राजनेता थीं वरन् विज्ञान एवं तकनीकी की उत्कट समर्थक भी थीं। समृद्धी अनसन्धान एवं विकास में उनकी गहरी रुचि से ग.स.वि.स. को अत्यधिक लाभ पहुँचा। यद्यपि वह अब हमारे मध्य नहीं हैं तथापि उनके विचार हमारे मस्तिष्क को प्रतिध्वनित करते रहते हैं।

इस वर्ष के अन्तर्गत संस्थान में कुछ प्लनगठन किये गये हैं। यथा वैज्ञानिकों के प्रशिक्षणार्थ एक नये योजना एवं प्रशिक्षण विभाग का गठन किया गया। संस्थान के सगणक सी.डी.सी. ३१६ को भी समृद्धी उपकरण विभाग से मिलाया गया। संस्थान के सभी शोध कार्य, ११ प्रमुख शोध परियोजनाओं के अन्तर्गत विभाजित किये गये। संस्थान की कुछ प्रमुख उपलब्धियाँ निम्नांकित हैं —

(अ) शोध एवं विकास कार्य

अन्य वर्षों की भाँति, संस्थान ने सागर विकास विभाग द्वारा आयोजित अन्टार्कटिका - अभियान में सक्रिय भाग लिया। संस्थान के एक वैज्ञानिक अन्टार्कटिका के दक्षिण गंगोत्री स्थित भारतीय केन्द्र में १ वर्ष रहकर अनसन्धान के व्यापक वापस आये। चौथे अभियान में भी इस संस्थान के ३ वैज्ञानिक सम्मिलित किये गये।

आर. वी. गवेषणी तथा ओ. आर. वी. सागर-कन्या की शोध यात्रायें भी निरन्तर होती रही। आर. वी. गवेषणी ने २५ शोध यात्रायें की जिन में सेशल्स मरुत्कार के अन्तरोध पर सेशल्स के समृद्धी आर्थिक क्षेत्र में आयोजित ३ यात्रायें भी शामिल हैं। इसी देश के लिये बहुधात्विक पिण्ड तथा समृद्धी शैवाल के लिये भी सर्वेक्षण किया गया। सागर-कन्या का भी भरपूर उपयोग किया गया। इसकी १०

शोध-यात्रायें हिन्द महासागर में बहुधात्विक पिण्डों की खोज हेतु आयोजित की गई।

समुद्री भौतिक विज्ञान के कार्यों में सैद्धान्तिक अध्ययन, आंकिक मॉडलिंग तथा दूर ध्वनि संवेदन (रिमोट सेन्सिंग) द्वारा सागरीय अध्ययन की प्रमुखता रही। सागर-कन्या का उपयोग करते हुये बंगाल की खाड़ी में मानसून तथा उसके बाद की स्थितियों के बारे में विषय अध्ययन किया गया। भारत के पूर्वी तट के निकट, बंगाल की खाड़ी में 'अपवेलिंग' का भी पता लगाया गया है। सागर-कन्या की एक अन्य शोध-यात्रा में केनिया के निकट, पूर्व अफ्रीका तट पर समुद्रीय धारा क्षेत्र के आंकड़े एकत्र किये गये, जिनके अध्ययन से यह विदित होता है कि उत्तरी क्षेत्र में धाराओं की तीव्रता अधिक है।

दक्षिण-पश्चिम भारत तथा सोमालिया के मध्य समुद्री पट्टी मिश्रित सतहों का अध्ययन किया गया जिसके द्वारा सुझाया गया कि एकत्रित उष्मा के संचारण के लिये दक्षिण पश्चिम मानसून के अन्तर्गत 'हॉरिजॉन्टल एडवेंशन' उत्तरदायी है। इसके साथ ही तटीय स्थिरता से सम्बन्धित अध्ययन भी होता रहा।

'रिमोट सेन्सिंग' विधि द्वारा सोमाली तट के निकट तीव्र 'अपवेलिंग' का भी पता चला है। अंतरिक्ष केन्द्र द्वारा संबंधित 'इन्फ्रारेड थर्मल स्केनर' तथा आयतित 'प्रिसिशन रेडियेशन थर्मोमीटर' द्वारा समुद्र में तापक्रम के आंकड़े लगातार प्राप्त किये गये।

प्रभागीय तौर पर सौर उष्मा तालाब का प्रयोग किया गया। प्रयोगशाला स्तर पर एक हल्का मॉडल 'ब्रेक वाटर सिस्टम' भी तैयार किया गया।

समुद्री जीव विज्ञान अध्ययन में लक्षद्वीप क्षेत्र में प्राथमिक उत्पादकों के लिये आवश्यक नाट्रोजन १५ का आंकलन एक महत्वपूर्ण उपलब्धि थी। उत्तरी अरब सागर की जीवमात्रा में 'पिको प्लैक्टन' का २० से २५% तक योगदान पाया गया है। समुद्री शैवाल के अध्ययन में 'स्कूबा गोताखोरी' तथा रिमोट सेन्सिंग विधियों की सहायता ली जानी शुरू की गई। गोवा तट से 'सिलोसिरा' की नई प्रजाति का पता भी लगाया गया।

यह पाया गया है कि हिन्द महासागर के केन्द्रीय एवं दक्षिणी भाग, गहरे समुद्र में पाये जाने वाले जीव जंतुओं की दृष्टि से अत्यन्त धनी और उपयोगी है। मिनी काय लंगून के प्रवाल क्षेत्र में तलीय जीवों का वहां पाये जानेवाली 'टर्टल घास' के साथ घना सम्बन्ध पाया गया है।

खाइच जीव जैसे ऑइस्टर, थ्रिम्प और म्लूट मछली की प्रजनन, संवर्धन एवं विकास की जानकारी हेतु प्रयोग शाला में अनेकें अध्ययन किये गये। सूक्ष्म जीव विज्ञान के अध्ययन के दौरान गोवा के निकट पाये जाने वाली मछलियों के नमूनों में 'ल्युमिनीसेंट बैक्टीरिया' की खोज भी की गई है।

संस्थान के एक वैज्ञानिक डा. धारगलकर, अंटार्कटिका में स्थित ऑस्ट्रेलिया के एक कैंप में १ वर्ष तक समुद्री शैवाल पर अध्ययन करके वापस आये।

इस वर्ष भारतीय पर्वी तट तथा अंटार्कटिका क्षेत्र में भी जैविक जमाव एवं जंग अध्ययन का विस्तार किया गया। परिणाम बताते हैं कि स्थिर बारनेकल समुद्र में उल्लंघन तत्वों की एकत्र करने की क्षमता रखते हैं। भारतीय समुद्र में 'टैरिडो मिनडैनसिस' का पहली बार पता लगाया गया।

रसायन विज्ञान विभाग ने फॉस्फोरस तथा नाइट्रोजन चक्रों के अध्ययन पर ज्यादा ध्यान दिया। कुछ जीवों में 'एंटीफर्टिलिटी' क्रिया के लिये उत्तरदायी तत्वों का पता भी लगाया गया। समुद्री कवई से कई यौगिक अलग किये गये जो कि एक या अनेक जैविक क्रियाओं के लिये उत्तरदायी हैं। इस सम्बन्ध में एक भारतीय-अमरीकी संयुक्त परियोजना भी शुरु की गई और ४ वैज्ञानिकों को तलाके सीधे अध्ययन और नमूने एकत्र करने के आधुनिक तरीके सीखने के लिये अमरीका भेजा गया।

भोपाल दूर्घटना की पृष्ठभूमि में समुद्री प्रदूषण अध्ययन विभाग ने 'मिथाइल आइसोसायनेट' के 'ब्लैकडाउन प्रोजेक्ट्स' तथा उनके दरगामी प्रभावों का अध्ययन प्रारम्भ किया है। बम्बई के निकट अक्टूबर - नवम्बर १९८४ में 'एम.टी. लाजपत राय' नामक जहाज की दूर्घटना स्वरूप फैले तेल से हुये प्रदूषण का अध्ययन भी किया जा रहा है इसके अतिरिक्त सतह की सूक्ष्म सतहों का अध्ययन करने हेतु एक 'स्क्रीन सैम्पलर' तथा समुद्री तलछट से कीटाणुनाशकों को अलग करने की विधियों का विकास किया गया है।

लक्ष द्वीप के उत्तर में गहरे समुद्र तथा भारत के दक्षिण पश्चिम तट के समुद्र में भूभौतिकीय अध्ययन किये गये। इसके अतिरिक्त चुम्बकीय 'एनामली' मानचित्र भी बनाये गये हैं जिनमें मुख्य-मुख्य लीनियामेंट और अन्तः सतह की पहचान की गई है। कोकण-तट पर समुद्र में इलमेनाइट भंडारों की जानकारी के लिये विषद भूभौतिकीय अध्ययन किये गये हैं। हिन्द महासागर की केन्द्रीय घाटी में बहु धात्विक पिण्डों के भण्डार हेतु ७० लाख किलोमीटर का क्षेत्र सर्वेक्षण किया गया।

प्राच्य जलवायु विज्ञान अध्ययन से यह पता चलता है कि अन्य उष्ण कटिबंधीय क्षेत्रों की तरह 'प्लिस्टोसीन' समय में भारत की जलवायु भी सूखी थी। बम्बई सौराष्ट्र क्षेत्र में फोरामिनीफेरा की २५ नई प्रजातियों की भी नई जानकारी मिली है।

भरसायन अध्ययनों से यह पता चलता है कि भारत के पूर्वी तट के समुद्र में पाये जाने वाले तत्व जैसे अल्यूमीनियम, लोहा, टिन, मैंगनीज, जस्ता, तांबा तथा निकल 'डेट्राइटल तथा नान डेट्राइटल' मूल के हैं। इन तत्वों के बनने, इधर उधर जाने तथा एक स्थान पर जमने के कारणों तथा विधियों से सम्बन्धित जानकारी का पता भी लगाया गया है। यह पता चला है कि यह तत्व मूलतः लोहे तथा मैंगनीज के ऑक्साइड कणों के साथ ही जमीन से समुद्र में आते हैं।

संस्थान के समुद्री उपकरण विभाग ने ओ. आर. वी. सागर कन्या से आंकड़ों को 'इंटेल्सेट बी' उपग्रह के जरिये सीधे संस्थान को भेजने की प्रणाली का विकास किया। समुद्र में सीधे संग्रह तथा उपग्रह द्वारा एकत्रित आंकड़ों की तुलना हेतु आर. वी. गवेषणी पर एक मौसम केन्द्र की स्थापना की गई।

समुद्री तकनीकी विभाग ने १०० मीटर तक गहरे पानी में सफलता पूर्वक 'मरिंग' की और यमन, यूरान तथा बम्बई के निकट 'वेव राइडर ड्याय' स्थापित किये। एक समान्तराल पर लहर एवं मौसम सम्बन्धी आंकड़े एकत्र किये गये हैं। विदेशों से मंगाई गई कुछ उन्नत कम्प्यूटर विधियों का आंकड़ों के विश्लेषण हेतु प्रयोग किया गया। संस्थान में विकसित एक विधि का विशालापट्टनम के निकट तट रेखा के बदलाव के अध्ययन के लिये सफलता पूर्वक प्रयोग किया गया।

एक अनुमोदित परियोजना के अन्तर्गत समुद्री परातत्व अध्ययन हेतु द्वारिका और बेट द्वारिका के समुद्र में सर्वेक्षण किये गये। इनमें सिन्धु घाटी की सभ्यता के समय की एक मोहर (सील) तथा कुछ इबे हये खंडहरों का पता चला है। इसके अतिरिक्त कुछ बर्तनों के नमूने इत्यादि भी प्राप्त हुये। इस अध्ययन ने भारत की प्राचीन सभ्यता एवं सागर सम्बन्धी इतिहास पर प्रकाश डाला है।

संस्थान की तरफ से संस्थान में ही अनेक विषयों के प्रशिक्षण की व्यवस्था की गई। इनमें संगणक एवं तैराकी के प्रशिक्षण भी हैं। इसके अतिरिक्त प्रशिक्षण हेतु पाठ्यक्रम भी तैयार किया गया।

संस्थान के शोध-पत्र महासागर को समयानुसार प्रकाशित किया गया और मार्च १९८५ तक का अंक निकाला गया है।

संस्थान के क्षेत्रीय केन्द्रों ने अपने-अपने क्षेत्र में स्वतन्त्र रूपसे महत्वपूर्ण कार्य किये। बम्बई केन्द्र ने बम्बई के निकटवर्ती समुद्र में तेल प्रदूषण से जीवों पर

होने वाले प्रभावों का अध्ययन किया।

कोचीन केन्द्र ने श्रीगा मछली के संवर्धन विकास पर अध्ययन किया। इसके अतिरिक्त 'एपसीडेस चिलकेनसिस (मछलियों का भोजन) के संवर्धन की विधियों का उन्नत बनाने के प्रयोग किये गये।

वाल्टेयर केन्द्र ने मुख्य रूप से भूमौतिक अध्ययन किये। बंगाल की खाड़ी में 'चम्बकीय एनामली' की गणना की गई। साथ ही समुद्री तलछट तथा प्रदूषण प्रवाह सम्बन्धी अध्ययन किये गये।

(ब) प्रायोजित परियोजनायें

प्रायोजित परियोजनाओं के द्वारा संस्थान ने और संगठनों की सहायता का कार्य जारी रखा। इस तरह की १७ नई परियोजनायें आरम्भ हुईं और इन से संस्थान को ७० लाख रुपये की प्राप्ति हुई। कई संस्थाओं को परामर्श देने का कार्य भी किया गया।

(स) सेवायें

सागर-कन्या पर उपग्रह संचार व्यवस्था स्थापित की गई। संगणक क्षेत्र में 'बेंसन ड्रम प्लॉटर तथा डिजिटर', 'आफ डाइव टेप ड्राइव' की अतिरिक्त व्यवस्था की गई। नोराड सहायता के अन्तर्गत एक अन्य सर्वाधृत संगणक एन. डी. ५२० भी स्थापित किया गया। यन्त्रोंके पाइलट परियोजना में आंकड़ा केन्द्र हेतु एक 'रेन बो १०० बी' संगणक भी स्थापित किया गया।

कार्यशाला (वर्कशॉप) को एक नये बड़े भवन में स्थानांतरित किया गया है तथा अनेकों संस्थाओं को संस्थान द्वारा उपयोगी समुद्री आंकड़े उपलब्ध कराये गये।

संस्थान की महत्वपूर्ण उपलब्धियों को प्रदर्शनीओं द्वारा पना तथा दिल्ली में प्रदर्शित किया गया। इसे अनेकों लोगोंने देखा और पसन्द किया।

(द) अन्य महत्वपूर्ण घटनायें

भारत के उपराष्ट्रपति श्री. एम. हिदायतुल्ला, उनकी धर्मपत्नी तथा श्री. के.टी. सताराबाला, लेफ्टीनेन्ट गवर्नर गोवा ने १४ फरवरी १९८४ को संस्थान का दौरा किया, जिसमें उन्हें संस्थान के कार्यकलापों से अवगत कराया गया।

पहली बार, १२ फरवरी १९८४ को बम्बई में हये राष्ट्रपति के अबलोकन हेतु बेडे में आर. बी. गवेषणी तथा ओ. आर. बी. सागर कन्या को सम्मिलित किया गया।

संस्थान ने यूनीडेप/यूनेस्को के 'समद्री दलदलीय बनस्पति' अध्ययन हेतु परे आरम्भिक प्रशिक्षण पाठ्यक्रम का आयोजन किया। इसके द्वारा इस विषय कार्य करने वाले अनेकों वैज्ञानिकों को परस्पर सम्पर्क में आने का अवसर प्राप्त आ जिससे दलदली क्षेत्रों के प्रबन्ध में सहायता मिलेगी।

भारत तथा पश्चिम जर्मनी के मध्य समद्री अध्ययन में सहयोग बढ़ाने हेतु एक कार्यशाला आयोजित की गई। नोराड के तत्वाधानमे एक कार्यशाला 'मल्टी नल साइसमिक डेटा' के संग्रह एवं विवेचन' शीर्षक के अन्तर्गत आयोजित की गई।

'सामाजिक गतिविधियाँ: सी. एम. आइ. आर. की अनेक प्रयोगशालाओं के मध्य आयोजित 'भटनागर टूर्नामेन्ट' में संस्थान की टीम को ३ परस्कार मिले। इनमें मार्चपास्ट में प्रथम, बास्केट बाल में द्वितीय तथा क्रिकेट में तीसरा स्थान प्राप्त हुआ। यह हर्ष का विषय है कि इस वर्ष संस्थान के पांच वैज्ञानिक भारतीय विज्ञान अकादमी, इलाहाबाद के सदस्य निर्वाचित हुये।

संस्थान के दो सदस्य श्री. बी. सधाकर (कनिष्ठ तकनीकी सहायक) तथा श्री. तलसीदास (सफाई कर्मचारी) की मृत्यु हम सभी के लिये शोक का विषय है।

डा. वी. वी. आर. वरदाचारी
निदेशक

I

Director's Report

This is the twentieth Annual Report of the National Institute of Oceanography, and it covers the fiscal year, 1984-85, to be in conformity with CSIR Annual Report, instead of the calendar year 1984, as was being done in previous years. Since the last Annual Report covered the period upto December, 1983, this report includes the activities from January, 1984 to March, 1985.

It is with great regret that we record here the unnatural demise of our Prime Minister Smt. Indira Gandhi who was also the President of CSIR. Smt. Gandhi was not only a statesman but an ardent supporter of Science and Technology. NIO greatly benefitted through her deep interest in Ocean Research and Ocean Development. Though she is no more, her ideas reverberate in our minds. The staff of NIO join the nation in paying homage to her.

During the year 1984, there have been some re-organisations in the Institute. A new Division of Planning & Training was formed in April to look after the work particularly of training of young oceanographers. The computer TDC-316 was attached to the Marine Instrumentation Division. The research activities have been brought under 11 major projects. Some of the important achievements of the Institute during this period are given below.

A. R & D ACTIVITIES

This year also, NIO participated in the Antarctic Expedition programme of the Department of Ocean Development (Govt. of India). A scientist from NIO stayed for a year at India's manned station at Dakshin Gangotri and has returned. In the Fourth expedition three scientists from NIO were included.

The cruises of RV **Gaveahani** and ORV **Sagar Kanya** were continued. Twenty five cruises were undertaken by RV **Gaveshani** including three cruises in the EEZ of Seychelles at the request of the Government of Seychelles. Surveys for polymetallic nodules and seaweeds were undertaken for the Government of Seychelles. ORV **Sagar Kanya** was utilized to the maximum and ten cruises were conducted mostly for survey of nodules in the Indian Ocean.

Theoretical studies, numerical modelling and remote sensing of oceanographic features were some of the new and important studies carried out by the physical oceanography group. A comprehensive study of the monsoon and postmonsoon conditions in the Bay of Bengal was undertaken using ORV **Sagar Kanya**. A strong upwelling in the southern Bay of Bengal off the east coast of India has been noticed. An analysis of the data of one of the cruises of ORV **Sagar Kanya** along the Kenyan coast, on the oceanographic conditions of the East African coastal current areas, showed that the current was stronger along its northern part.

Studies on the mixed layer along a strip from the southwest coast of India to Somalia were also made and the simulation suggested that the horizontal advection during the southwest monsoon provided the needed transport mechanism for the accumulated heat. Studies on beach stability were continued.

Remote sensing techniques have indicated an intense upwelling off the Somali coast. An Infra-red Thermal Scanner developed by the Space Applications Centre and an imported Precision Radiation Thermometer were operated for recording continuous sea surface temperature.

An experimental solar pond has been operated. A laboratory model of a portable breakwater system has been designed.

The highlights of biological investigations were the estimation of nitrogen uptake by primary producers using N^{15} in the Lakshadweep region. In the northern Arabian Sea, picoplankton was found to contribute 20 to 25% of the biomass. Marine algal survey with the help of SCUBA diving and remote sensing techniques was initiated. A new species of **Coelosira** was reported from Goa. Studies were also conducted on the marine algal resources of the Seychelles islands.

The deep sea benthos in the central and southern part of the Indian Ocean was found to be diverse, rich and productive. In the Coral Atolls in the Minicoy lagoon, the benthic fauna was found to be related to the density and biomass of the turtle grass. The culture, breeding and growth studies on edible oyster, shrimp and mullets were successfully undertaken. During microbiological studies luminescent bacteria were detected in fish samples from Goa waters.

Dr. Dhargalkar, Scientist in the Biological Oceanography Division of our Institute stayed for one year at an Australian Station at Antarctica, and returned after an extensive study of the various aspects particularly algal resources.

Biofouling and corrosion studies have been extended on the east coast of India and some panels have been exposed in Antarctica waters as well. The results indicated that sessile barnacles could accumulate trace metals. **Teredo mindanensis** was found to be a new record for Indian Waters.

Chemical Oceanography laid emphasis on the phosphorus and nitrogen cycles and speciation of important metals. A regeneration model was constructed for flux evaluation of trace metals (**in-situ**) considering theoretical and practical aspects. The fractions responsible for the antifertility activity in some of the organisms have been indicated. Several compounds from marine algae have been isolated which have shown one biological activity or the other. An Indo-US project on biologically active organisms was taken up and as a first step, four scientists were deputed to U.S.A. for training in diving for **in-situ** studies and collection of samples.

The Marine Pollution Division has carried out some studies on the long term effects of breakdown products of Methyl isocyanate (MIC) which leaked out in large quantities from a factory in Bhopal. The work is in progress. NIO actively participated in monitoring and containing the oil spill due to the accident on M.T. **Lajpatrai** off Bombay in October-November, 1984. A screen sampler for surface

micro-layer studies has been designed and also a new method for extraction of pesticides from sediments using electrolytes has been developed.

Geophysical studies were made in the deep sea areas north of Lakshadweep and on the continental shelf off the southwest coast of India. Besides, some magnetic anomaly maps were prepared and major lineaments and basements were identified. Detailed offshore surveys along the Konkan coast were carried out for ilmenite placers. Over 0.7 m. sq. km. of area was surveyed in the Central Indian basin, for nodule deposits.

Paleoclimatic studies indicated an arid climate during the late pleistocene as in other tropical areas. As many as 25 species of foraminifera are found to be new along the Bombay-Saurashtra coast.

Geochemical investigations of elements such as Al, Fe, Ti, Mn, Zn, Cu and Ni in the sediments of the eastern continental shelf of India showed that all these elements had both detrital and non-detrital components. The mechanism of formation, transportation and deposition of the non-detrital components has been thoroughly investigated. Oxides of iron and manganese seemed to be the main carriers of major portion of trace elements from fluvial to marine environment.

In the Instrumentation Division, a facility has been developed to transmit oceanographic data from **ORV Sagar Kanya** to NIO through a satellite, IN-TELSAT V. Development of a weather station on board **RV Gaveshani** was taken up to collect ground truth data for remotely sensed satellite data. This instrument has been designed around INTEL 8086.

The Ocean Engineering group of the Institute designed mooring systems for depths upto 100 m and wave rider buoys were successfully deployed off Yanam and Uran and off Bombay High. Simultaneously time series data on waves and meteorological parameters were collected. The software packages, "DUCHESS" for storm surge model, and "DOLPHIN" for wave hindcasting model, from the Netherlands, are being used for analysing the data. An analytical model was developed and tested successfully to study shoreline changes at Visakhapatnam.

Marine archaeological investigations were conducted under Grant-in-aid project in the water of Dwarka and Bet Dwarka under west coast. Two significant results of the studies in Dwarka were the discovery of a unique seal of the Indus valley civilization and the identification of submerged structures. In addition to this, many specimens of pottery and other wares were collected. These studies have thrown light on the past civilization and maritime history of India.

The Institute initiated inhouse training in various fields. Three courses on computer programming and two on survival swimming have been conducted. A syllabus for oceanographic training is being prepared.

The Institute's Bulletin "Mahasagar" has been brought uptodate.

The Regional Centres continued working on independent projects covering oceanographic studies in their areas. The Bombay Centre studied the effects of pollutants, particularly oil, on marine organisms, in the waters off Bombay.

The Cochin Centre worked on the growth of prawns. Culture techniques for **Apeudes chilkensis** — a feed organism — were developed.

At the Regional Centre, Waltair, the emphasis during the year was on geophysical studies. Magnetic anomalies in the Bay of Bengal have been computed. Sediment transport and transport of discharged pollutants formed part of the studies of Visakhapatnam harbour.

B. SPONSORED WORK

The Institute continued to serve other organisations through sponsored projects. During the year, twenty one new sponsored/grant-in-aid projects were undertaken for which the Institute received an amount of over Rs. 82 lakhs. Consultancy services were also provided to some agencies.

C. SERVICES

A satellite communication system was installed and commissioned on board **RV Sagar Kanya**. The computer centre has been upgraded with a Benson Drum Plotter, off-line Magnetic Tape Drive Unit and Benson Digitizer. A more sophisticated and faster computer ND-520 was received and commissioned. This has been possible under the NORAD Technical Assistance programme. A RAINBOW 100B computer was received at NIO Data Centre under the UNESCO pilot project.

The workshop has been shifted to its new and spacious premises and has been provided with additional facilities like overhead gantry crane, precision lathes, radial drilling machines, etc.

A good number of books and journals were added to the library. This year a large amount of oceanographic data was provided to the users of outside organisations.

The activities and achievements of the Institute were displayed at important exhibitions held at New Delhi and Pune, during the year and a large number of people saw these exhibits.

D. OTHER IMPORTANT EVENTS

The important event during the year under report was the visit of Vice-President of India Shri M. Hidayatulla, accompanied by his wife and Shri K.T. Satarawala, Lt. Governor of Goa, Daman & Diu on 14th February, 1984. They were apprised of the various activities of the institute.

For the first time **RV Gaveshani** and **ORV Sagar Kanya** were included in the President's Review of Ships, held on 12th February, 1984, at Bombay.

The Institute organised the 2nd UNDP/UNESCO Introductory Training Course on Mangrove Ecosystems. This helped in bringing together scientists and other personnel working in this field and in evolving a common strategy for proper management of mangroves.

An Indo-FRG Workshop on Marine Sciences, for collaboration in oceanographic research between the two countries, and an Indo-NORAD workshop on "Acquisition, Processing and Interpretation of Analog and Multi-channel Seismic Data" were held at the Institute.

Social Activities: The Institute's team bagged three prizes during the S.S. Bhatnagar Memorial Tournament, held at Hyderabad for the various CSIR laboratories. These include, first prize in March Past, second prize in Basketball and third prize in Cricket.

It is a matter of great pleasure that five scientists of this Institute have been elected Fellows of the National Academy of Sciences, Allahabad, this year.

I record with profound grief, the sad and untimely demise of two of our staff members, Shri B. Sudhakar Rao (Junior Technical Assistant) and Shri Tulsi-das (Safaiwala).

Dr. V.V.R. Varadachari
DIRECTOR

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List of Projects under study

1. Studies on air-sea interaction and physical processes in the seas around India.
2. Remote sensing of oceanic parameters and features of the seas around India.
3. Chemical studies of the waters and the bioactive substances of the seas around India.
4. Protection of marine environment and monitoring of pollutants along the Indian coast.
5. Regional geology, geophysics, geochemistry, paleoclimatic and foraminiferal studies of the sediments of the continental margins of India.
6. Survey of polymetallic nodules.
7. Assessment and evaluation of living resources of the seas around India.
8. Ocean engineering studies related to coastal and offshore development.
9. Development of marine instrumentation systems including data buoys along the Indian Coast.
10. Coastal zone management.
11. Ocean modelling.

3. Research Activities

3.1

Physical Oceanography

3.1.1 Ocean modelling.

3.1.2 Studies on air-sea interaction and physical processes in the seas around India.

3.1.3 Coastal zone management studies.

3.1.4 Remote sensing of oceanic features/parameters.

A. R & D PROJECTS

3.1.1. Ocean modelling.

Under this project, the following investigations were carried out:

(a) Storm Wave Hindcasting:

The first phase in the adaptation of the Tohoku Numerical wave model to the north Indian ocean, which was taken up earlier, has been completed. Programmes have been developed for the computation of wind field associated with severe cyclonic storms. The simulation of the wind field through the model agreed fairly well with the observed wind field for a severe cyclonic storm in the Bay of Bengal.

In yet another study, Duchess model was modified for the simulation of M_2 component of tide in the Bay of Bengal. Numerical experiments were performed with the actual bathymetry of the region concerned and the model simulated well the M_2 component of tide.

A parametric type of cyclone model was developed as part of the computation of the surges along the Indian coasts. The cyclone model gave good results for wind velocity and wind stress fields. This cyclone model was coupled with tide model to make it a surge model. Numerical experiments on surges were performed for the Arabian Sea. It has been found that the surge model gave very high elevation within few hours of numerical integration of the model. However, the model needs proper calibration for the realistic simulation of surges along the Indian coasts.

(b) Mixed Layer Modelling:

A modified Kraus-Turner mixed layer model has been used to identify factors responsible to the variability of monthly-mean sea surface temperature along

a zonal strip extending from the southwest coast of India to Somalia. The observed monthly-mean heat and momentum fluxes, advective field etc. serve as inputs to the numerical experiments carried out with the mixed layer model.

It has been noticed that the observed SST along the strip goes through four well marked phases (1) a warming phase from approximately February to May, (2) cooling from May to August, (3) warming from September to mid November and (4) cooling from mid-November to January. The numerical experiments carried out suggest that during the two warming phases the mixed-layer shallows due to detrainment. The increase in SST is predominantly due to heat gained at the surface. During the winter cooling phase the mixed layer deepens: cooling occurs due to entrainment of the underlying waters into the mixed layer, and also due to loss of heat at the surface. During phases (1), (2) and (4) the rate of change in SST predicted by the model forced by surface fluxes alone compares favourably with the observed rate of change over most of the strip. During May-August, in the coastal region, upwelling due to offshore Ekman transport occurs. The resulting shallowing of the mixed-layer enhances cooling by untrapping. In the offshore areas, downwelling occurs due to Ekman convergence. This depresses the interface between the mixed-layer and the seasonal thermocline, thereby retarding the cooling due to entrainment across the interface. Strong horizontal temperature gradients and large surface velocities occur during this period, specially in the western Arabian Sea and add significantly to the cooling produced by other factors.

The strip examined here, virtually like all of the Arabian Sea, is a region of net annual heat gain by the oceans. Hence, to maintain the annual cycle of the vertical thermal structure there has to be a transport mechanism to carry away the accumulated heat. The simulations carried out suggest that the horizontal advection during the southwest monsoon season provides such a mechanism.

(c) Seasonal variation of salinity in the Zuari estuary:

The Zuari estuary is shallow and narrow. An interesting feature of this estuary is its well marked seasonal variation in salinity. From October to late May, the dry period, the salinity steadily increases. With the onset of the southwest monsoon, the salinity drops and continues to decrease till September. Available observations in the estuary show little stratification both laterally and vertically. Making use of this property, a one-dimensional advection-diffusion model has been used to simulate the seasonal variability of the salinity as a passive tracer. As seen from Figures 1 and 2 the predicted salinity variation agrees well with the observations. This suggests that (1) The dominant processes controlling the transport of salt on a seasonal time scale in the Zuari estuary are horizontal turbulent diffusion along the axis of the estuary, and mean advection controlled by runoff. (2) A dispersion relation of the type $K(x) = K + f(R/A)$ seems adequate to model the turbulent transport. In the above expression K is the turbulent diffusivity, R is the runoff and A is the cross-sectional area of axial location x . K' and f are empirically determined: the former is a constant and the latter is a function of R/A .

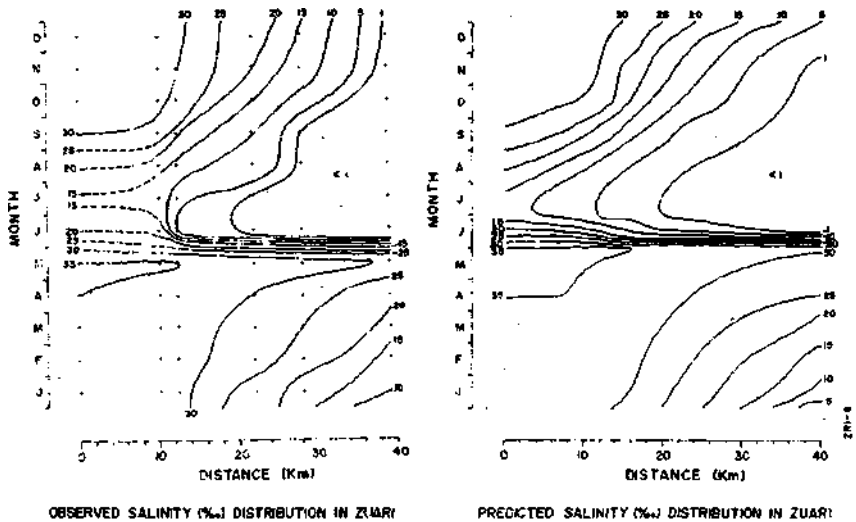


Fig 2

(d) Long Waves:

(i) The propagation of the quasi-geostrophic shelf waves along a rough coastline with a steep shelf was studied. A boundary perturbation and the Fokker-Planck equation was used to show that the mean wave does not decay in the direction of propagation because these waves cannot be backscattered.

(ii) The transmission of Rossby waves across a midoceanic ridge with a rough top was investigated using a variation of Khasminkii's limit theorem. The rough ridge, like a patch of roughness on the sea floor, acts like an effective barrier for shorter waves.

(iii) Scattering of Rossby waves from an irregular coastline, modelled as a strictly stationary random process, was also studied. Using Wiener-Hermite expansions, the coherent reflection and the angular distribution of the scattering were found. The existence of a set of modes trapped at the wall was established.

(e) Acoustic Modelling:

Range dependent software programme for sound ray paths in SOFAR channel has been developed. Further modifications are in progress to incorporate the bottom topography along the vertical slice and also the computation of intensity of sound along the ray path for different sources and receiver configurations. Theoretical study of the inverse problem to obtain the sound speed profile from arrival sequence of sound signals has been investigated. The relevant software has also been developed.

3.1.2 Studies on air-sea interaction and physical processes in the seas around India.

Under this project several field surveys have been carried out. In addition, large quantities of data collected earlier have been processed. The following are some of the salient features of these studies.

(a) Bay of Bengal:

During July-October, 1984 extensive field surveys of the Bay of Bengal have been carried out on board **ORV Sagar Kanya** between 4° and 21° N. Zonal sections were occupied at 2° intervals in the Bay of Bengal. In addition, ten sections normal to the east coast of India were occupied with station intervals ranging from 10 to 20 nm. A total number of 185 stations were occupied during the 90 day cruise programme. The CTD system has been operated at all the stations. Simultaneously, soft-ware programmes have been developed to process the data using the computer facilities available on board. In particular, the following programmes have been finalised and used.

- (i) Regression equations for applying correction to temperature and salinity data obtained from CTD.
- (ii) Dynamic computations involving computation of density, Sp. vol. anomaly, dynamic depths and other parameters like sound velocity, potential temperatures and in-situ density.
- (iii) T-S plots on the computer.

Distribution of temperature along three sections 4° , 12° and 18° N. was studied (fig. 3). A characteristic feature is that the thickness of the mixed layer decreases from south to north from about 90 to 20 m during southwest monsoon period. The bottom of the thermocline could be demarcated by the 13°C isothermal surface in the south while 12°C isothermal surface lurns the bottom of the thermocline in the north. Further studies on thermal structure are in progress. The preliminary studies indicate that thermohaline circulation is a dominant phenomenon in the coastal regions.

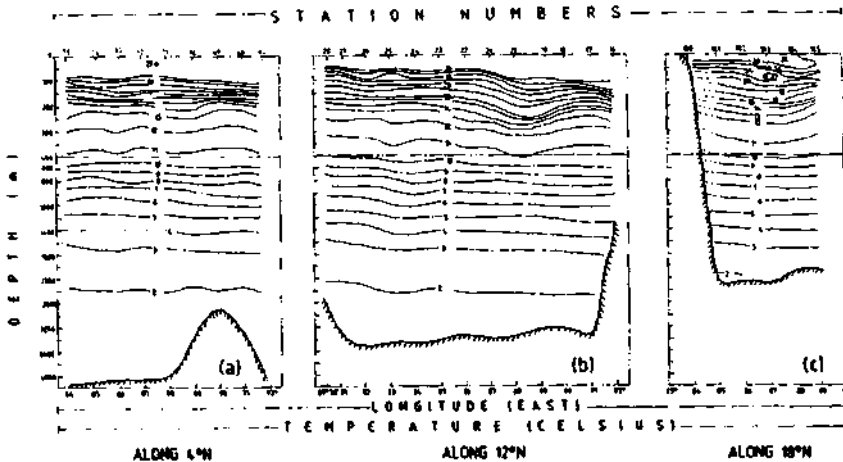


Fig.3: THERMAL STRUCTURE

Utilising the data collected during IIOE and the data collected subsequently, a study on the salt balance and mixing in the Bay of Bengal has been taken up. The contributions of the surface processes of evaporation, precipitation and run off to the salinity budget have been estimated and a study of the advective salt transport is being made.

Based on the hydrographic data collected during August-September, 1978 in the western Bay of Bengal the flow pattern have been deduced. The analysis indicates the following features:

- (i) Strong upwelling in the southern regions off the east coast of India which is not in evidence in the northern region.
- (ii) The presence of a meandering front off the central east coast of India (off Visakhapatnam) separating the northern dilute coastal waters from relatively southern saline water.

(b) Arabian Sea and the Northwestern Indian Ocean:

The data collected during the 1st four cruises of **ORV Sagar Kanya** covering the monsoon and post monsoon seasons of 1983 have been partially analysed. Some of the salient results derived from the data collected in the north-western Indian Ocean during July-September, 1983 are:

The sea surface temperature was generally less than 26° in the sea off the coasts of Kenya and Somalia and the vertical distribution of temperature along 10° N reflect the influence of strong upwelling off the Somalia coast. The mixed layer thickness, in general, varied between 50 and 150 m, the higher values being encountered along 57° E. A comparison of vertical temperature profiles for locations 5° N, 57° E and 0° , 52° E obtained at an interval of 2 to 3 weeks, revealed significant decrease (upto 2° C) in the temperature of the mixed layer. The surface salinity, in general, decreased towards south, the lower values (less than 35 ppt) being encountered in the southeastern part of the study area.

The East African Coastal Current was stronger (speed upto 80 cm/sec) along the northern part of Kenya coast than along the southern part. The surface temperature and salinity of the coastal waters are around 25.4° C and 35.6 ppt respectively.

Light penetration in the open sea off the Kenya Coast was fairly high. There was no appreciable difference in transmittance between coastal waters and open sea probably due to the presence of corals.

The data collected on board **ORV Sagar Kanya** in the Arabian Sea during September-November, 1983 showed the remnants of strong monsoon circulation in the central portion of the Arabian Sea even after the relaxation of the winds. The response of the sea to the northerly winds takes place in a relatively short time scale of the order of a few days. Associated with the coastal circulation, a fairly strong counter current was observed along the west coast of India.

(c) Marine Meteorological and Air-Sea Interaction Studies:

(i) Using the sea surface temperature data from GOSSTCOMP charts produced by NOAA and the west coast monsoon rainfall data, a study has been carried out to examine the relationship of west coast rainfall with SSTs over the Arabian Sea. The study revealed the following:

The area of surface waters encountered by 27-28° C SST range seems to influence the monsoon rainfall pattern during the season over the west coast of India. The correlation coefficients between the area of 27-28° C SST range and the west coast rainfall are high (low) in the eastern Arabian Sea during good (bad) monsoon years.

(ii) Based on the data collected on board four Russian Ships forming a stationary polygon over the central equatorial Indian Ocean during 25-31 July, 1977, heat budget of the upper 200 m of the water column, the heat and water vapour budgets of the atmosphere (surface to 500 mb) have been computed. The following are the results:

In general, net heat loss from sea to the atmosphere is observed while the heat content of the upper layer of the oceans has shown a steady increase. The advective transport is presumed to be important in the heat budget computations.

The orders of average precipitation as estimated separately by the water vapour budget method as well as by cumulus parameterisation technique are well compared and are in close agreement with the observed rainfall at Minicoy Island.

The average rate of heating in the atmospheric column (surface to 500 mb) is considerably small (0.02°C/day). The loss of dry state energy is nearly compensated by the precipitation heating in the marine atmosphere.

The marine atmospheric boundary over the polygon area does not show layered structure which indicates instability due to strong convection in the atmosphere.

3.1.3 Coastal Zone Management Studies.

a) Land-sea interaction studies:

In this project, studies on beach stability and sediment transport along the Central Kerala Coast. nature and behaviour of coastal currents in the coastal boundary region and monitoring the coastal zone for upwelling have been carried out.

Following are the salient features of these investigations:

(i) Beach stability studies: Comparative studies made on the computer for wave heights based on deep water waves with those observed in the nearshore regions during field surveys indicated significant differences at locations where mudbanks are reported to be active. These differences resulting in greater percentage dissipation of wave energy in the region of mudbanks have been attributed to the increased viscosities of the fluid during the monsoon season (fig. 4 A and B)

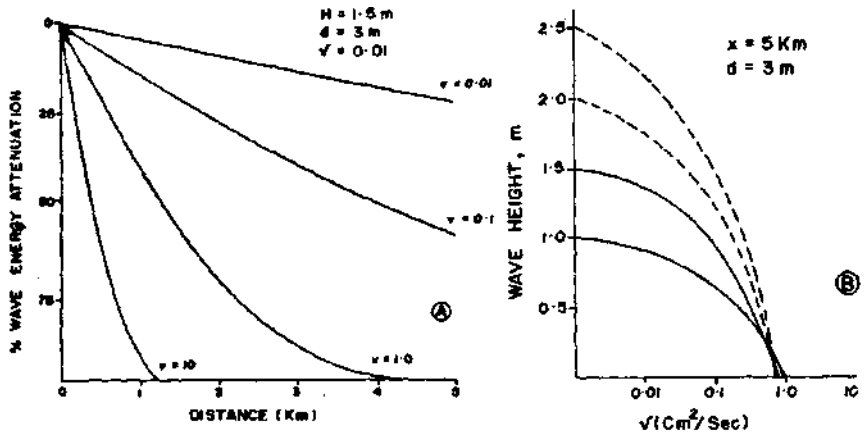


Fig. 4 Wave damping at the Mud Banks:

- (A) Percentage wave energy alternation for different kinematic viscosities (water depth 3 m)
- (B) Reduction in wave height with kinematic viscosity over at 5 km wide mud bank.

Converging and diverging flows are observed in the long shore currents along this stretch of the coast with a net southerly component. Owing to the limited supply of sandy sediments to this stretch (either from mainland or sea sources) these flows which are undersaturated with the sediments give rise to removal of beach sediments.

The general distribution of sediments of the beaches which are in fine to medium size limits indicate low wave energy environment prevailing along this part of the coast. The longshore sediment drift computed based on the annual wave energy has been found to be comparable to the sediments dredged from the outer channel of the harbour at Cochin.

The beaches free from the influence of artificial shore-protection structures or naturally occurring mud banks have been found to present cyclic features in response to the wave and wind climates. The magnitude of these changes, however, vary widely, from one location to the other.

The morphological studies of the beach of Valiathura indicated onshore and offshore movement of beach sediments controlling the erosion or accretion taking place with a pivotal point situated at a water depth of 1.8 m from mean sea level (Fig. 5 A, B and C). More than 90% of the observed variability in the beach profiles has been found to reflect on the mean beach profile (μ_1) with the remainder as seasonal (μ_2) and short term (μ_3) changes. This variability as represented by the mean beach profile appear to be controlled by 70% of the variability observed in the wave energy which has two peaks associated with waves of periodicity 12.5 sec. and 8.0 sec. in a year.

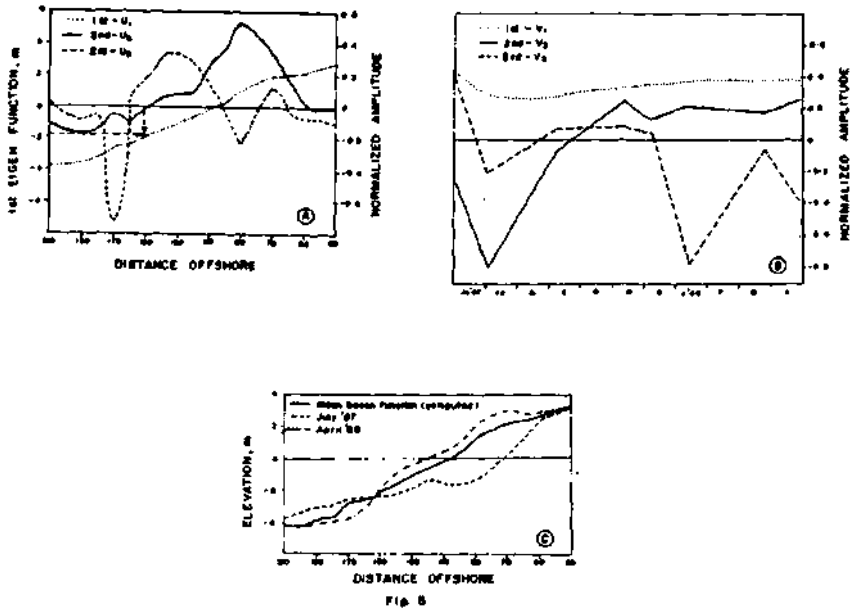


Fig. 5 A) The spatial dependence of the eigen functions for the Valiathura Beach, Kerala. First function (μ_1) represents the mean beach profile, while the second function (μ_2) represents the seasonal onshore/offshore sediment motion with a pivotal point at a depth of about 1.8 m below the MSL and the 3rd function (μ_3) represents the beach fluctuations.

B) The temporal structure of the eigen functions for the Valiathura beach, Kerala represents the time dependence of spatial functions shown in (A). 1st function (V_1) shows the stable nature of the beach over the study period 2nd function (V_2) shows the cyclic changes taking place and the 3rd function (V_3) shows the irregular periodicity of the beach fluctuations.

C) Mean beach profile — computed through the EOF analysis — lies in between the two extreme profiles with the pivotal point occurring at 2.3 m below MSL.

Data on the surface winds for four years at selected locations along the west coast of India analysed to examine the local air circulations indicated significant difference in the times of onset of sea breeze and its duration. The extent to which this feature affects the wave energy over short-time scales and the consequent wave induced flows controlling the sediment movement in the shore zone is being studied.

ii) Studies on coastal current: In order to understand the nature and the behaviour of the coastal currents at depths, current meter moorings have been laid for durations of 10 to 15 days during January, May and December. 1984 These studies were confined to the coastal boundary zone along the 15° N Lat on the western continental shelf and the analysis of data is progressing.

b) Solar Pond:

During this year an experimental solar pond has been commissioned. The pond consists of 9 m³ capacity FRP tank with 9m² surface area. 2.25 m² base area and 1.5 m height. The lower half of the tank is insulated to prevent heat losses. The experimental pond has been set up recently and regular measurements of temperature are being carried out.

3.1.4 Remote Sensing of Oceanic Features/Parameters.

(a) SST variation over Indian Ocean in relation to monsoon:

A study on satellite derived SST over the northern Indian Ocean and its seasonal variations with special reference to monsoon dynamics has been carried out using GOSSTCOMP (weekly averaged) charts for two contrasting years of monsoon (viz., 1979 and 1983). The results of the study are as follows:

- (i) Development of Somali current/Somali upwelling is very clearly seen as is the upwelling along the Arabian Coast.
- (ii) Spreading of upwelled water off the Somali coast is seen to split into two subsystems.
- (iii) At times temperature minimum is displaced from the shoreline. This may be probably due to topographic (shelf break) effect.
- (iv) Intense upwelling is seen to correspond well with good monsoon activity over India. This is reflected in the large negative zonal anomalies in SST observed off the Somalia and Arabian coasts during the year of good rainfall over India (1983).

(b) Optical properties and radiation transfer in the sea:

With a view to explore the possibilities of improving existing algorithms for quantitative estimation of suspended sediments and chlorophyll and to determine the confidence level of the values of the parameters obtained by remote sensing, theoretical and experimental studies on the spectral optical signatures of marine substances and the radiation transfer in the sea have been initiated.

A model of radiation transfer in the sea, using Monte-Carlo techniques, has been developed for studying variations in reflectance as a function of water quality and water type. Experimental studies on the optical properties of the suspended and dissolved material and parameters of radiation transfer in the sea are being carried out to verify the results of theoretical studies. Spectral data on downwelling and upwelling irradiances at various depths in the sea off the west coast of India have been collected in different seasons with Quanta Spectrometer on board the Institutes Research Vessel **Gaveshani**. Field data collected so far compare well with the preliminary results of theoretical studies.

A theoretical study of the variations in polarisation ratio and absolute values of light reflected at the sea surface as a function of sea state, has been carried

out. The possibility of using these parameters for remote sensing of sea has been examined. The results are being finalized.

(e) Upwelling along the west coast of India:

A collaborative experiment with Space Applications Centre to study upwelling along the west coast of India has been taken up during the year. Under this programme, five scientific cruises have been carried out in the study area on board RV **Gaveshani**, during January, May-June, December 1984 and oceanographic data on ocean currents, chlorophyll, primary productivity and meteorology have been collected. These data are being processed and analyzed and will be studied in conjunction with the remote sensing data from the satellites like NIMBUS-CZCS, NOAA-AVHRR and LANDSAT-MSS for the study area.

An Infrared Thermal Scanner, developed by Space Application Centre (ISRO) was operated from RV **Gaveshani** during a cruise in the eastern Arabian Sea in summer (April, 1984) and data on SST was recorded continuously along the cruise track. A precision Radiation Thermometer, procured from abroad, was operated from RV **Gaveshani** in the sea off the west coast of India in winter (December, 1984) and data on SST was recorded continuously along the cruise track. These data are being processed and analysed.

(d) Bhaskara-II SAMIR data utilization:

Water vapour content in the atmosphere over the Arabian Sea was computed from Bhaskara-II SAMIR data from June 1982. From these values, the distribution of water vapour in the atmosphere over the Arabian Sea has been studied in relation to monsoon activity. Water vapour content in the atmosphere was found to be more in the Central and south-eastern parts of the Arabian Sea. This feature could be attributed to the large evaporative flux, a characteristic feature of the central Arabian Sea for this period and the high precipitation experienced in the south-eastern Arabian Sea during the study period.

B. SPONSORED PROJECTS

Details of work carried out are given under chapter on "Sponsored / Grant-in-aid Projects".

3.2

Chemical Oceanography

3.2.1. Chemical studies of the waters and the bioactive substances of the seas around India.

A. R & D PROJECTS

3.2.1 Chemical studies of the waters and the bioactive substances of the seas around India.

- a) **Chemical studies in the coastal and offshore waters of the Arabian Sea and Bay of Bengal.**
- i) **Cycle of phosphorus and nitrogen compounds in the marine and estuarine environments:**

having 0.15 to 0.18 ml/l dissolved oxygen was observed between 150 and 1000 m depth with a primary peak of nitrate at 75 to 100 m and a secondary maximum at about 300 m along a section of 15°N. Nitrate showed a maximum between 150 to 300 m at all deep stations south of 11°N but did not show marked concentration north of 11°N. Phosphate concentration was moderately low but showed a regular trend of variations with depth.

In the Central Arabian Sea, the ratio of apparent oxygen utilization (AOU) to the nitrate and phosphate regeneration was found to be AOU: NO₃: PO₄ - 238: 14.3:1 by atoms. Using the above ratio a relationship between reserved nitrate and reserved phosphate has been obtained as follows:

$$(\text{NO}_3)_r = 13.71 (\text{PO}_4)_r + 0.016.$$

The vertical distribution of nutrients at some of the deep stations showed apart from the primary and secondary nitrite maxima, a tertiary nitrite maximum in the near bottom waters. The occurrence of this tertiary nitrite maximum associated with low dissolved oxygen leads to the conclusion that the organic matter that sinks to the bottom in unoxidised or partially oxidised state due to slow oxidation at the upper layers caused by insufficient oxygen supply, gets oxidised in near-bottom waters which is comparatively rich in oxygen.

ii) **Chemical speciation of important metals in sea and estuarine waters:**

Investigations were carried out on the speciation of Cd, Pb and Cu in the marine and estuarine regions. Labile cadmium varied from 0.12 to 0.7 µg/l whereas the total Cd ranged between 0.3 to 1.5 µg/l. Labile lead and copper showed variations between 1.2 to 2.8 µg/l and 0.67 to 2.0 µg/l respectively. Variations in the concentration of total lead was more (2.2 to 6.0 µg/l) compared to total copper (0.3 to 2.5 µg/l).

Studies carried out in the lagoons of Lakshadweep indicate that concentration of the labile form of cadmium was comparatively more (0.16 to 2.8 $\mu\text{g/l}$) inside the lagoon than outside (0.06 to 0.77 $\mu\text{g/l}$). The organically bound form varied from zero to 0.24 $\mu\text{g/l}$ both outside and inside the lagoon. The concentration of lead was comparatively high. Labile lead ranged between 0.9 and 4.0 $\mu\text{g/l}$ inside the lagoon and 0.9 and 1.4 $\mu\text{g/l}$ outside the lagoon. Not much variation in the concentrations of organically bound lead was noticed in the lagoon. Labile copper varied from 0.9 to 3.31 $\mu\text{g/l}$ inside the lagoon whereas outside it was between 0.67 and 1.4 $\mu\text{g/l}$. Organically bound copper concentration was 0.8 $\mu\text{g/l}$ both inside and outside the lagoon.

iii) Studies on fluoride and bromide:

Distribution of the different species of fluoride and bromide in the marine and estuarine regions have been carried out. The average F/Cl ratio for the Arabian Sea was 6.72×10^3 . In the coastal waters comparatively less bromide was observed after the monsoon which indicate heavy precipitation and subsequent dilution of surface waters. Bromide was $65.49 \pm 0.16 \text{ mg/l}$ with a Br/Cl ratio of 0.003477 ± 0.000002 at few stations near Minicoy.

In the Mandovi-Zuari estuaries an assessment was made on the effects of mixing processes on the distribution of fluoride. At the mouths of the rivers the ranges of variations are 1.28 to 1.31 mg/kg (premonsoon); 0.12 to 1.16 mg/kg (monsoon); 1.13 to 1.28 mg/kg (post monsoon). At the head of the estuary fluoride concentration varied from 0.08 to 0.14 mg/kg and 0.09 to 0.15 mg/kg for rivers Mandovi and Zuari respectively with an average value of 0.12 mg/kg for the freshwater.

iv) Organic constituents of sea water:

The role of the enzyme phosphatase on the phosphorus cycle in Mandovi estuary was studied. It was found that phosphatase activity was induced when phosphorus concentration became limiting and repressed under conditions of excess phosphorus. At the head of the estuary the activity was high (0.175 mg/g/min) and it was low (0.482 mg/g/min) at the mouth of the estuary. Among the samples collected from Bombay High, Lakshadweep and other regions of the Arabian Sea, highest activity was observed in the lagoons.

v) Regeneration models for trace metals:

A regeneration model was constructed for flux evaluation of trace metals *in situ*, considering theoretical and practical aspects. Concentrations of metals in total or in different ionic states, metals in particulate phase, temperature, salinity, oxygen, titration alkalinity, calcium, nitrate, phosphate and silicate were taken into account to evaluate the fluxes *in situ* to a first approximation. Through this evaluation metal removed could be estimated which in turn facilitates the estimation of removal time, residence time and removal rate constants not only for the normal ocean, but for the oxygen minimum zone also.

vi) Cation hydrolysis and regulation of trace metal composition in sea water.

Cation hydrolysis with implications to regulation of trace metal composition in sea water from 2°C to higher temp, at the mid-oceanic ridge by thermodynamic calculations was studied. An increase in the neutral metal hydroxyl species with increase in temperature was observed. During hydrothermal mix-

ing, transformations from lower positive hydroxyl species to higher or neutral complexes would occur for Cd, Ce, Co, Cr (III), Cu, Ni, Pb and Zn. From solubility calculations it was found that Al, Bi, Cr (III), Si, Fe and Th were saturated with respect to their oxyhydroxide solids at sea water concentrations at 25°C. Cu, Hg, Ni and Zn were found to reach saturation equilibrium at 250°C whereas Co, Mn, Pb exhibit under saturation. Linear relations have been observed for the metal-first hydrolysis constants and the percent total metal hydroxyl complexes with the elemental residence time in sea water.

vii) Property-Property relation:

a) Property relationships of some of the physical and chemical parameters such as salinity, potential temperatures, NO, PO, Oxygen and stability of water were studied at the discontinuity layers formed at 10° and 20°C potential temperature in the Arabian Sea and Bay of Bengal. These discontinuity layers may be found by the mixing of the water masses. The 20° discontinuity layer found between 150-200 m depth has a sigma-t of 25.3 and might have been formed by the mixing of southern subtropical anticyclonic gyre and the Persian Gulf water. The 10° discontinuity layer which has sigma-t of 27.2 at 600 m depth formed by mixing of Red Sea water and the Northern Indian Ocean bottom water.

b) Organic chemicals from the sea.

The project "Organic Chemicals from the Sea" was undertaken in collaboration with CDRI, Lucknow with a view to exploit hitherto untapped vast marine resources of Indian seas. So far, over 140 marine organisms have been screened for the wide spectrum of biological activities. Forty-two in these exhibited promising results.

Concentrated extracts from 25 new species which included sponges, corals, holothuria, seaweeds and other marine organisms collected from Andamans. Malvan and Ratnagiri were prepared for screening to assess their biological activity.

Aqueous fractions of *Corallina officinalis* and *Gemmaria - II* were tested at Central Drug Research Institute and found to be spasmogenic and toxic respectively. Hexane fraction of *Acanthophora specifera* was observed to exhibit antifertility activity.

Gobius fish available in Philippines, Formosa and few islands of Japan have been reported to be toxic to humans and ducks. In order to ascertain the nature of *Gobius sp.* available in Goan estuaries, a scheme has been initiated. One of its species, *Trypauchen vagina* available from the mouth of Zuari river was subjected to bioassay tests on mice. The crude extract when administered from 200 to 500 mg/kg showed no abnormal behaviour or animal mortality. However, the non-toxic nature of the fish remains to be confirmed.

Chemical investigations of marine organisms.

a) *Stoechospermum marginatum*:

In addition to the compounds reported earlier (stoechospermol, its acetate and fucosterol), two more compounds corresponding to the Rf values of dihydrostoechospermols have been isolated from this seaweed. Characterisation of these two compounds by spectral data is being carried out and the presence

of the fatty acids, oleic, palmitic acids and ethyl palmitate has also been confirmed.

b) Padina tetrastromatica:

The fatty acid fraction from this algae was found to contain hexadecanoic, octadecanoic, dodecanoic, oleic, methyl decanoate and methyl oleate, C-32 ester consisting of long chain residues in both alcohol and acid portions of the molecules has been isolated.

c) Spatoglossum asperum:

Chemical investigation of the algae resulted in isolation of six pure compounds. Two of these appear to be saringasterol and fucosterol on spectral evidence.

d) Gemmaria sp. II:

The crude extract of this organism which exhibited highly toxic properties was further fractionated into organic soluble and aqueous fractions. The organic soluble fraction was found to contain mostly fatty acids and esters on the basis of chemical investigations. The aqueous fraction which is responsible for high toxicity is being further tested at CDRI.

e) Acanthus ilicifolius:

Chemical investigation of the chloroform fraction of the mangrove plant resulted in the isolation of four compounds, three of which were identified as 2-Benzoxalinone, linolic acid and a fatty ester $C_{15}H_{31}CO.OC_{16}H_{33}$. Structural elucidation of another compound which appears to be a triterpenoid is being carried out.

f) Porites Lutea:

The ester waxes isolated from the lipid fraction of stony coral **Porites Lutea** were characterized by IR, HNMR, and mass spectrometric techniques. The compounds thus characterized are stearyl palmitate palmityl palmitate; palmitoleyl palmitate and myristyl palmitate.

g) Estimation of Vit E in seaweeds:

Tocopherol content of different seaweeds belonging to the family **Rhodophyta**, **Chlorophyta** and **Phaeophyta** has been estimated. The results indicate that the concentration of Vit. E is highest in Phaeophyta, intermediate in **Chlorophyta** and lowest in **Rhodophyta**.

3.3

Marine Pollution Studies

3.3.1 Protection of marine environment and monitoring of pollutants along the Indian Coast.

A. R & D PROJECT

3.3.1. Protection of marine environment and monitoring of pollutants along the Indian Coast.

1. Petroleum hydrocarbons

a) Dissolved/dispersed petroleum hydrocarbons:

During cruise 130 along the east coast of India, between Visakhapatnam and Nagapatnam, 27 water samples were collected from different depths (0, 10 and 20 m) and analysed for dissolved/dispersed petroleum hydrocarbons. The concentrations varied between N.D. (not detectable) and 3.4 $\mu\text{g/l}$ (av. 1.6 $\mu\text{g/g}$). The analysis of 15 sediment samples showed that oil content varied from 2.4 to 10.6 $\mu\text{g/g}$ dry weight (av. 5.3 $\mu\text{g/g}$).

During the cruise 139 water samples at 14 stations were collected and analysed for dissolved/dispersed petroleum hydrocarbons. The values varied between 18.6 and 114.6 $\mu\text{g/g}$ (av. 39.6 $\mu\text{g/l}$). These values were about 1 to 3 times higher than those along the east coast of India. Also 14 sediment samples from the Arabian Sea were analysed for petroleum hydrocarbons and the concentrations ranged between 0.78 and 6.0 $\mu\text{g/g}$ (av. 2.7 $\mu\text{g/g}$).

During the cruise 143, thirty six water samples and 12 sediment samples were collected and analysed for petroleum hydrocarbons. Hydrocarbons in waters ranged between 16 and 18.9 $\mu\text{g/g}$ (av. 7.7 $\mu\text{g/g}$) and in sediments, it varied from 5.2 to 15.8 $\mu\text{g/g}$ (av. 9.8 $\mu\text{g/g}$).

From the data, it becomes clear that so far there is practically no oil pollution along the east coast of India, in conformity with our earlier observations. Along the west coast oil pollution is restricted only to water, as sediment shows similar concentration in both the areas.

b) Floating petroleum residues/tar balls:

During cruise 130 Neuston net was towed at few stations along the oil tanker route but it did not show presence of tar particles. During cruise 143A in the Arabian Sea, Neuston net was towed at 1 m depth for about 10 minutes at a speed of 2 knots at different stations. Only traces of tar balls could be observed.

c) Identification of sources of oil pollution at Mormugao Harbour:

At the request of Mormugao Port Trust a total of 7 samples from two suspected ships and from harbour waters were analysed to identify similarities, if any, between them. Internationally recommended procedures for such purposes viz.. (i) Gas Chromatography - to identify peaks at different retention times,

(ii) Infrared Spectroscopy — to identify peaks for different organic compounds and to calculate ratios between significant wave lengths and (iii) Spectrofluorometry — to examine similarities in wave lengths for peak emission keeping excitation wave length constant were applied to all the samples and observed similarities between quite a few of them. Representative data have been reproduced in Figure 6.

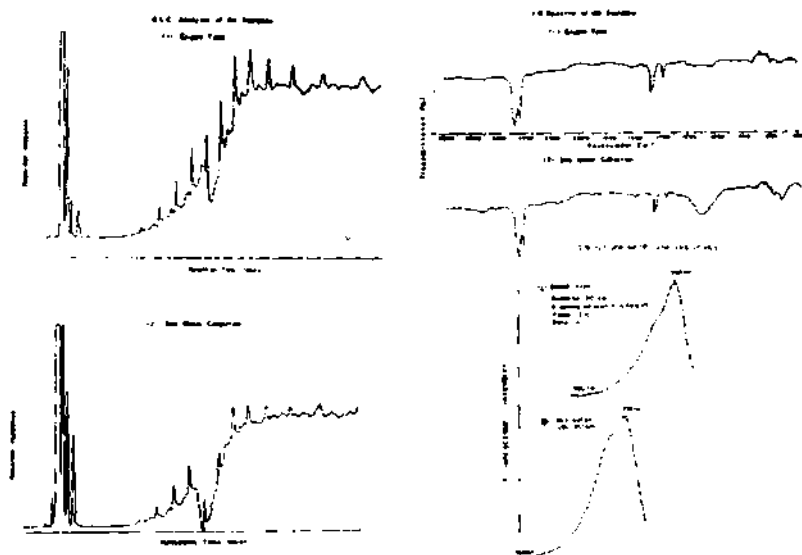


Fig 6

d) Monitoring of oil spill due to accident on M. T. Lajpatrai:

During the last week of October, 1984, the oil tanker M.T. **Lajpatrai** of Shipping Corporation of India caught fire while at anchor off Bombay. The ship was fully loaded awaiting lightering. After 2-3 days the ship started listing on its aft. The fire was in its own bunker and some oil was spilled therefrom. NIO, as a member of the action group for national contingency plan on oil spills, very actively participated in fighting the spill. Oil in water and sediments were monitored from 31st October to 13th November. Initially surface concentrations ranged from 27-118 $\mu\text{g/l}$ and concentrations at a depth of 5 m ranged from 36-59 $\mu\text{g/l}$. The sediments had 40-512 μg of oil per gram of dried sediment. When observations were called off, concentrations ranged 17-32 $\mu\text{g/l}$ at the surface and 7-22 $\mu\text{g/l}$ at 5 m depth which were quite close to the ambient concentration. The dispersant, which was used to control the spill was also tested to examine the suitability of application to Indian condition.

2. Toxic and non-toxic heavy metals.

a) Analysis of water samples:

About 200 water samples collected during cruise 4 of ORV **Sagar Kanya** in central Arabian Sea have been analysed for various trace metals and interpretation of the results is in progress.

In addition to this, results of trace metal analysis from Mandovi — Zuari waters are being processed to interpret the data in relation to different seasons and variations in salinity.

b) Analysis of marine organisms:

Investigations were continued on the monitoring of toxic heavy metals in marine biota along the Indian coast, more specifically from the EEZ. While the levels of Hg, Cd and Pb were determined in about 50 zooplankton samples, 200 fishes belonging to various levels in food chain were analysed for these three elements in muscles, liver, gill, heart, kidney and ovaries. The results have confirmed earlier findings on levels of the elements. The data on experimental studies on the uptake of these elements support the results obtained in natural habitat, i.e. in tissues of fishes which show preferential accumulation of each metal. Hg is accumulated mostly in muscles while Cd and Pb in liver and gills respectively.

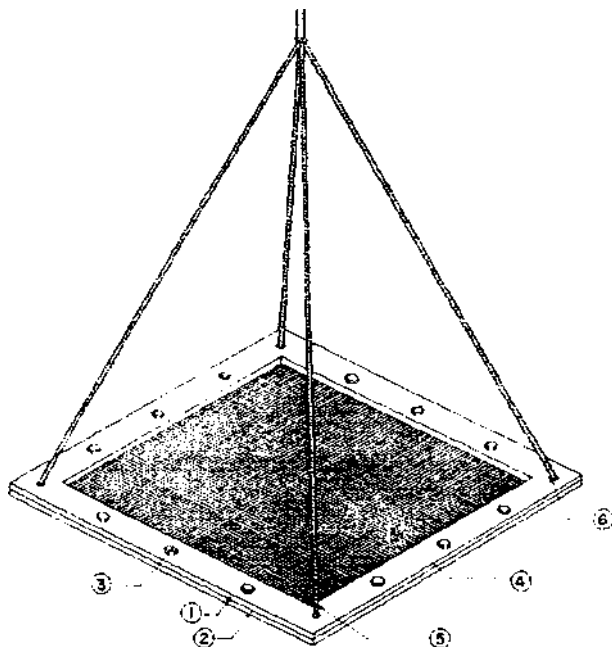
At the request of Karnataka State Water Pollution Board, the fish samples from Binage Bay off Karwar were analysed for mercury. Its value ranged between 0 to 0.02 ppm wet weight and showed no effect of mercury pollution on the fishes.

c) Analysis of sediment samples:

About 74 surface sediment samples from all along the Indian coast and a low core samples were analysed for Hg, Cd and Pb. Hg was observed at the levels of 0.05 ppm (dry wt.) in all the samples, while Cd levels varied from <1.0 - 220 ppm where about 80% of the samples showed less than 1.0 ppm. Values for Pb too varied from <1.0 ppm - 368 ppm with about 50% values equal to or <1.0 ppm. The distribution of these elements with depth showed no regular pattern. More data are necessary to get a clear picture as far as levels of these potentially toxic metals in sediments are concerned.

3. Chemistry of sea surface microlayer.

The physico-chemical properties of the sea surface have a significant effect on the processes of exchange of chemicals across the air-sea interface. Marine plants and animals may be involved in air-sea exchange in a number of significant ways. They produce surface active organic material which can alter exchange through the formation of films at the air-sea interface and on air bubbles and particles moving towards the interface and consequently the surface microlayer is enriched in pollutants compared to waters directly beneath it. Little or no information exists in India on levels of pollutants in the interface. The most difficult problem for such a study is the sampling of the microlayer. A screen sampler (Fig. 7) for surface microlayer suitable for our conditions has been designed and fabricated. Working of the sampler has been tested in the field. Samples were collected from the surface microlayer and the water immediately below it. Preliminary analysis have been conducted on the enrichment of nutrients in these layers.



SCREEN SAMPLER FOR SEA SURFACE
MICROLAYER COLLECTION

- | | |
|-----------------------|-------------------------|
| (1) ACRYLIC FRAME | (4) POLYETHYLENE SCREEN |
| (2) ACRYLIC FRAME | (5) NYLON STRING |
| (3) PVC NUT AND BOLTS | (6) HOLE FOR SUSPENSION |

Fig. 7

4. Organochlorine and organophosphorous pesticides in the marine environment.

a) Marine and estuarine environment:

During cruise 141 of R V Gaveshani in Hooghly estuary and adjacent waters sediment and zooplankton samples have been collected for the analysis of organochlorine and organophosphorous pesticides.

A new method has been developed for the extraction of pesticides from the sediments using different electrolytes, e.g. NaCl, KCl, NH₄Cl, BaCl₂ and AlCl₃. Attempts are being made to determine the fate of some organophosphorous pesticides namely D.D.V.P., monocrotophos, phosphamidon etc., in marine sediments with and without the metallic ion and also in brackish water on pH 8.5.

b) After effects of MIC leakage in the aquatic environment of Bhopal

NIO scientists participated along with several other CSIR, ICAR, ICMR and government organisations and studied the effects of the leakage of about 40 tonnes of the deadly poisonous gas Methyl Isocyanate (MIC) from the Union Carbide Factory at Bhopal on 2-3 December, 1984 in the aquatic environment.

MIC undergoes a series of exothermic reactions with water in equimolar proportions producing various bye-products e.g. N-methylcarbamic acid, N-N'-dimethyl urea, trimethyl iso-cyanuoric acid, etc. But the end-product of all these in excess amount of water is mono-methyl amine.

There are two lakes at Bhopal. One of them, the Upper Lake, is the source of water supply to the city and is quite far away from the source of MIC leakage. The other one, the Lower Lake, is very close to the factory and smaller in area, and is completely eutrophicated.

The concentrations of mono-methylamine, ammonia-nitrogen and urea in water collected at different depths of the lakes, and the bio-accumulation of methylamine in fishes were measured. MIC inhibits acetyl choline esterase (AChE) activities of the human blood and the same can be expected to occur for fishes as well. A few blood samples from MIC-affected patients were collected and the AChE in them in different fish tissues were measured. The data are presented in Tables I through V.

pH values of the Lower Lake waters are more alkaline than that of the Upper Lake water (Table I). Ammonia and urea concentrations in the samples of the waters of the Lower Lake were also comparatively higher than those in the Upper Lake. The abnormally high concentration of ammonia (21.07 mg/l) at 10 m of the Lower Lake clearly indicates the eutrophicated condition near the bottom. For a comparison, pH, urea and ammonia in tap water were also estimated. These values appear to be within permissible limits.

TABLE I - pH, AMMONIA AND UREA IN LAKE AND TAP WATER OF BHOPAL

Location	Depth (m)	pH	NH -N (mg /l)	Urea-Nitrogen (mg /l)
Tap water	—	7.70	2.75	4.25
Upper Lake	0	7.91	5.04	4.7
Lower Lake	0	8.39	5.49	5.5
Lower Lake	5	8.31	5.04	5.17
Lower Lake	10	8.18	21.07	5.25

Methylamine concentrations in the Lower Lake water (0.03 µg/l at surface and 0.05 µg/l at 5 m) are fairly low while it is not detectable at the surface of the Upper Lake (Table II). This indicates that the Lower Lake, being nearer to the factory than the Upper Lake, seems to be somewhat affected by MIC.

TABLE II - METHYLAMINE CONCENTRATION IN LAKE WATERS OF BHOPAL

Location	Depth (m)	Methylamine ($\mu\text{g/l}$)
Upper Lake	0	Net detectable
Lower Lake	0	0.03
Lower Lake	5	0.05

Some bio-accumulation of methylamine was observed in muscle, swim bladder and gills of the fishes from the Upper Lake (Table III). The gall bladder of **Labeo calbasu** appeared distended. Concentration in **Barbus stigma** from Lower Lake was fairly high.

TABLE III - METHYLAMINE CONC. IN FISH COLLECTED FROM LAKES IN BHOPAL

Species name	Length cms.	Sex	Methylamine conc. ppb wet wt. in			
			Muscle	Swim- bladder	Gills	Whole fish
Labeo calbasu (U.L.)	36.5	M	N.D.	5.42	9.74	
Labeo gonius (U.L.)	42.0	M	4.75	N.D.	4.22	
Puntius serrana (U.L.)	27.0	F	4.13	—	N.D.	
Mastacemphalus sp. (U.L.)	53.0	F	4.47	—	N.D.	
Ompok bimaculatus (U.L.)	23.5	F	N.D.	—	—	
Barbus stigma (L.L.)	8.0	—	—	—	—	919
Unidentified (L.L.)	11.0	—	—	—	—	N.D.
Unidentified (L.L.)j	6.0	—	—	—	—	N.D.

N.D. = Not detectable; U.L. = Upper Lake; L. L. = Lower Lake.

AChE activities indicated somewhat lower values in fishes from the Lower Lake, than those from the Upper Lake (Table IV) which, perhaps, indicate some inhibition by MIC.

TABLE IV - ACETYLCHOLINE-ESTERASE ACTIVITIES IN DIFFERENT ORGANS OF FISHES COLLECTED FROM LAKES OF BHOPAL

Species name	Acetyl-choline-esteras (AChE) activities (μ moles/gm wet wt)			
	Muscle	Gills	Liver	Intestine
Labeo calbasu (U.L.)	60.0	37.67	28.84	22.32
Labeo gonius (U.L.)	67.31	40.19	29.53	26.6
Puntius serrana (U.L.)	66.48	43.40	33.33	22.85
Mastacemphalus sp. (U.L.)	54.27	34.9	—	—
Orapok bimaculatus (U.L.)	69.81	42.23	—	—
			Viscera whole	
Barbus stigma (L.L.)	54.34	33.33		25.25
Unidentified (L.L.)	47.36	34.48		24.24
Unidentified (L.L.)	47.09	35.55		21.27

U.L. = Upper Lake; L.L. = Lower Lake

AChE activities of the blood plasma of the MIC-poisoned patients are highly significant. The values (Table V) are well below the normal range of 90-150 μ moles/ml of blood plasma. This is an indication of some sort of neurological disorder in the nervous system.

TABLE V - ACETYL-CHOLINE-ESTERASE ACTIVITIES OF BLOOD PLASMA OF SOME MIC-POISONED PATIENTS AFTER THREE WEEKS.

Age of the patients (all male)	AChE activities μ moles/ml of plasma
45	54.54
35	57.14
25	68.18
40	75.0

Characteristics of estuarine regions of major rivers in India.

During cruise 141 of R V **Gaveshani**, a survey of the estuarine region of the river Hooghly and the mouth of the river Mahanadi was carried out. Six anchor station stations each of over two tidal cycles duration were occupied, out of which 3 stations were inside the river Hooghly and one each at Sandheads, of New

Moore Island and off the mouth of the river Mahanadi. At the anchor stations meteorological data and currents were recorded every 3 hours and hydrographic casts and plankton hauls were also taken every 3 hrs. Sediment samples were collected by Van Veen, Petterson grabs and box corer for the analysis of benthic fauna, humic acids, petroleum and chlorinated hydrocarbons.

3.4

Geological Oceanography

- 3.4.1 Geochemistry of the sediments of the continental margins of India.
- 3.4.2 Geological and geophysical surveys to decipher the regional geology and to assess the petroleum and mineral prospects of the continental margins of India.
- 3.4.3 Regional geology and manganese nodules deposits in the central Indian basins of the Indian Ocean.
- 3.4.4 Paleoclimatic studies on the nature of the summer monsoon over India during the past ten thousand years.
- 3.4.5 Foraminifera as indicators of pollution in the marine environment.

A. R & D PROJECTS

3.4.1 Geochemistry of the sediments of the continental margins of India.

Geochemistry of the sediments of the eastern continental shelf of India was studied and studies of the bulk and partition geochemistry of Al, Fe, Ti, Mn, Ni, Cu and Zn of the following areas were completed.

- i) Ganges-Brahmaputra shelf
- ii) Visakhapatnam-Kakinada shelf
- iii) Kakinada-Pennar shelf
- iv) Pennar-Calimere Point shelf.

The results are given below:

1. In the Ganges-Brahmaputra shelf, lower concentrations of all the elements are associated with the sandy sediments and the higher concentrations with clayey sediments. In the Visakhapatnam-Kakinada shelf, the elemental concentrations follow closely the zonation of the sediments. High concentrations of all the elements are associated with the nearshore and slope clays, medium concentrations with the sand-silt-clay zone and the low concentrations with the relict band of sediments and the nearshore sands. Towards the southern end of this unit, the influence of Godavari river is clearly seen from the presence of terrigenous clayey sediments all over the shelf and the high concentrations of the elements associated with them.

In the Kakinada-Pennar shelf region which is under the influence of the major rivers and is carpeted by brown and green clay, uniformly high concentrations of all the elements are encountered both in the shelf and slope regions. The concentrations of Fe, Mn, Ti and Cu, except Zn and Ni are far higher than those recorded in the two northern units. Among the elements studied, in respect to Mn only a conspicuous depletion is noticed in the days of the slope relative to the nearshore.

In the Pennar-Calimere Point shelf, in the region between Pennar river and Pulicat Lake, the sediment distribution is patchy, in that, both sand and clay occur all over the shelf while clay alone is present in the slope. Consequently, the values of elements are low in sands and high in clay all over the shelf. South of Pulicat Lake where the shelf is mostly covered by sand and the slope with clay, the concentrations of the elements are low in the shelf and high in the slope.

2. Geochemical investigations on deep sea cores from Indian Ocean.

Five cores collected from east to west along 12° S Lat. were studied for their sedimentological and geochemical characteristics. The sediments were found to be bi-modal and mainly composed of both siliceous and calcereous foraminifera. Geochemical analysis have shown that the cores have less than 10% of CaCO₃ while they are considerably enriched in manganese and depleted in Al and Fe. Concentrations of all other elements were similar to near shore sediments.

3.4.2 Geological and geophysical surveys to decipher the regional geology and to assess the petroleum and mineral prospects of the continental margins of India.

RV **Gaveshani** carried out about 3000 line kilometer echosounding, sidescan sonar, seismic profiling (ORE subbottom and 16 kilojoules sparker) and magnetics in the deeper area north of Lakshadweep and on the continental shelf of the southwest coast of India. The training under the NORAD assistance programme was conducted during the former cruise.

The bathymetric and total magnetic intensity data off the Kathiawar and Ratnagiri coast collected during earlier cruises have been analysed and magnetic anomaly maps at 50 nT contour interval have been prepared. The magnetic anomalies depict some of the major lineaments and basement trends in the area. Two-dimensional model and spectral studies of the anomalies under constraints from seismic, and palaeomagnetic data revealed the nature and structure of the basements.

An east-west trending lineament parallel to 21 degrees north end meeting the coastline a little north of Veraval is identified as a major fault which perhaps better represents the offshore extension of the northern boundary of the Narmada fault on the continental margin off Saurashtra. The magnetic basement is at shallow depth in the areas north of this lineament and deeper in the south.

The magnetic anomaly map for the inner shelf of Ratnagiri was prepared at a contour interval of 50 nT. The map reveals a N-S trend of the anomalies. The two-dimensional model and spectral studies of the anomalies revealed that the anomalies are due to the magnetic crystalline basement about 1.7 km thick at a depth of 1.0 to 1.2 km which is similar (in magnetisation) to onshore basalts of NW India. In the midshelf to shelf edge north of Devgad the magnetic basement is perhaps deeper and considerable thickness of sediments may be expected. Whereas in the similar areas south of Devgad magnetic basement is perhaps at the comparatively shallow depth. These studies confirm downfaulting of onshore Deccan basalts into Arabian Sea and covered by the tertiary sediments subsequently.

During the ORV **Sagar Kanya** cruise 12, echosounding 4980 line km, gravity 4980 line km, magnetic 4980 line km, seismic reflection 3368 line km and seabed sampling (3 box cores, maximum length 5.9 m, one grab and one dredge) at five locations were carried out between water depths of 60m to 4500m off Konkan.

During **RV Gaveshani** cruise 150 echosounding 1725 line km, side scan sonar 900 line km, ORE-subbottom profiling 1725 line km and 1475 line kilometres of sparker were carried out followed by surface sediment sampling (35) on the continental margin off Saurashtra.

An appraisal of the previously collected data on seabed conditions in an area of over 72,000 sq. km. on the inner and midshelf between 18° N and 21° N of the northwestern continental shelf of India was also completed. The inner-shelf in the north (the Gulf of Khambhat) is characterised by uneven topography (to 13m) chiefly due to NNE-SSW trending sand banks and the intervening channels filled by about 5m thick clays. The banks are superposed by NNE-SSW sand waves (3-4m high), mega ripples and ripples due to the high energy tidal regime of the Gulf. The sand banks taper off (at 20° 50' N; 28m depth) and further the seabed is covered by clays and marked by even topography. The thickness of clays increases further SSW at 28-30m depth to about 50-55m. Between 28 to 38m water depths in an area of approximately 2500 sq. km the clays are marked by extensive masking due to gases (about 11.5 percent methane). The seabed between Bombay and the Bassein field (50-55m) in the west is marked by even topography and is covered by 20 to 30m thick acoustically transparent clays. The clays attain the maximum thickness (20-30m) at about 25m to 30m water depth and thin gradually to the west, where the underlying relict sands of 10,000 yrs. BP out-crop at water depth of 60-65m. The transition is marked by NNW-SSE trending sandy ridges (4-5 metres high, 1-2 km wide). The outer midshelf sandy areas are characterised by uneven topography (upto 15m) chiefly due to relict forms in oolitic, coral and algal limestones and oolites etc. and 1 to 2m high (100 to 200m wave length) NNE-SSW trending relict sand waves.

The 650 km of high resolution seismic reflection profiles in the Bombay Harbour have been analysed. Three sedimentary units were identified to lie over the acoustic bedrock: these are the late Pleistocene consolidated sediments, early Holocene layered sediments and modern clays. An unconformity probably caused by subareal erosion during Pleistocene lower sea strand separates the consolidated sediments from the overlying layered sediments. The layered sediments were deposited during early Holocene marine transgression when the climate was perhaps moister than present and the monsoon used to be periodically more intense and short lived. The modern clays lie conformably over the layered sediments and was deposited during the last about 700 years: during which the climate remained semi arid similar to the present day. The bedrock appears to be fractured, eroded and tectonically disturbed but no evidence was observed for post Holocene disturbance.

Geomorphological work on coastal and offshore areas of Maharashtra and Goa is in progress.

Exploration for offshore ilmenite placers off Konkan, Maharashtra

The high resolution shallow seismic records indicated 3-4 well defined

horizons within the top few meters of sediments and the acoustic basement is characterised by undulations. The total intensity magnetic field in these is superimposed by high frequency and large amplitude to medium amplitude anomalies which are identified as due to heavy minerals over a regional magnetic field. The regional magnetic field correlates well with the Deccan basement. Some structural elements were identified with magnetic maps their trends are similar to those of onshore (N-S, NW-SE & NNW-SSE). Magnetic model studies over the placer deposits and the synthetic anomalies generated show a positive correlation with the heavy mineral concentrations. Model studies for basement configuration for the all 13 bays are in progress.

LANDSAT imagery has been used to study the distribution and dispersion of turbid water masses on the western continental shelf of India.

3.4.3 Regional geology and manganese nodule deposits in the central Indian basins of the Indian Ocean.

Detailed surveys for polymetallic nodules in the Central Indian basin have been carried out on board of ORV **Sagar Kanya** and the chartered vessel MV **Farnella**. Over 0.7 million sq. km was surveyed and about seven tonnes of samples of bulk nodule were collected for metallurgical studies. The studies included echosounding, magnetics and gravity measurement along with preliminary meteorological data. The nodule analysis was carried out at eight different laboratories. At the request of the Seychelles Government, surveys were earned out in their Exclusive Economic Zone.

Basic research on polymetallic nodules has been undertaken in various fields of geology and geophysics. Similarly indigenous development of various instruments has been undertaken.

3.4.4 Paleoclimatic studies on the nature of the summer monsoon over India during the past 10,000 years.

1. Feldspars and quartz contents of sand and silt fractions of forty three samples from the western continental shelf of India were determined by X-ray diffraction method. The results indicate that the feldspar content in the relict (9,000-12,000 years B.P.) outer continental shelf sediments exceeds the feldspar content in modern inner continental shelf sediments. The types of feldspar are maximum and intermediate microcline, orthoclase and high albite.

The paleoclimatic inferences drawn from these data are that the climate during the late Pleistocene and early Holocene was arid. These findings are in general agreement with the climate of other tropical areas for that period.

2. An investigation has been made on a sediment core from the upper continental slope off Saurashtra coast. Analysis were carried out to estimate the calcium carbonate and coarse fraction content in addition to planktonic foraminifera and clay mineralogy. Based on the calcium carbonate and planktonic foraminiferal data, a boundary between glacial and interglacial is placed at 42 cms assuming the sedimentation rate as 4 cms/1000 years. Distribution of calcium carbonate clearly shows the sharp change in its abundance at the 42 cms. boundary. Among planktonic foraminifera, **Globigerinoides sacculifer** and **G. ruber** are by far the most abundant. The variation in the planktonic foraminiferal fauna

is not as sharp as CaCo₃ because of the insignificant change in the temperature during glacial and interglacial periods of late Pleistocene. Some species of **Orbulina** viz. **O. bilobata** and **O. suturalis** were encountered and believed to be reworked ones. Distribution of clay minerals such as illite and chlorite along with quartz show an increasing trend towards the bottom of the core in the glacial period. This may reflect the fluctuation in the sediment discharge from the river Indus. Whereas, in the interglacial period this was not encountered and may be attributed to the existence of a dynamic barrier in Holocene.

3.4.5 Foraminifera as indicators of pollution in the marine environment.

i) Samples were collected from the offshore region (77-201m depth) off Karwar. The sediment was characterised by opaline silica, fossilised larger foraminifera mixed with the recent living forms and also the recently-dead large-sized benthic foraminifera (e.g. **Elphidium indicum**). The planktonics included **Globoquadrina conglomerata** and **Globigerina hexagona** and dexirally coiled **Neogloboquadrina pachyderma typica setty**. It is interesting to note that **G. conglomerata** and **G. hexagona** which apparently disappeared from the Atlantic at the end of the last Interglacial (50,000 to 1,000,000 years ago) are found to be living in this region. The occurrence of dexirally-coiled **N. Pachyderma typica Setty** in these waters is suggestive of upwelling and its record in the sediment as indicative of such water masses having been present in the region. The presence of larger forms like **Amphistegina bicirculata**, **A. radiata** var. **papillosa** and **Operculina ammonoides** indicate mixing while **Nummulites cumingii** and **Borelis schlumbergeri** are relict forms of Pleistocene. The opaline silica was deposited during the close of the Pleistocene or the beginning of the Holocene time.

ii) Fossilised fungal spore remains of the sediment cores taken from the shelf-slope-basin regions off Bombay-Saurashtra Coast in the Arabian Sea indicated an assemblage of 12 genera and 42 species of which **Polycellaesporites** and 25 species are new to the literature whereas **inapertisporites** is the most common element of the assemblage as represented in the entire area.

iii) A quantitative analysis of Miramar-Caranzalem shoreline of Goa revealed that the variation in the density of the suspended load in the waters of monsoon and non-monsoonal periods is a direct reading of the contained foraminiferal concentration as observed at various stations. Similarly, temperature, salinity and tidal effect during monsoon and non-monsoonal periods exerted a profound effect on productivity and quality of preservation.

B. SPONSORED PROJECTS

Details of work carried out are given under chapter on "Sponsored / Grant-in-aid Projects".

3.5

Biological Oceanography

3.5.1 Assessment and evaluation of living resources of the seas around India.

3.5.2 Coastal Zone Management (Coastal Aquaculture).

3.5.3 Marine microbiological studies in the seas around India.

A. R & D PROJECTS

3.5.1 Assessment and evaluation of living resources of the seas around India.

a) Primary Production:

During RV Gaveshani cruise 132, stress was laid on the studies of primary productivity and uptake of extracellular products by heterotrophic bacteria along the south west coast of India. The results showed that column primary productivity varied from 0.8 - 1.73 gC/m²/d, chl a from 1.9 to 5.4 mg/m³ and ATP at the surface from 0.002 to 0.47 µg/l. Bacterial heterotrophic activity of extracellular material released during photosynthesis was observed in the euphotic zone. Suspended matter at the-surface varied from 8.34 to 20.94 mg/l. During RV Gaveshani cruise 136 nitrogen uptake by primary producers was investigated in the Lakshadweep region. N¹⁵ was used for the first time during this cruise and uptake of 15NO₃, 15NH₄, 15N-urea and ¹⁴C-urea were investigated.

An intense **Trichodesmium** red tide was noticed at 15°20'N and 73°4'E spread over 600 km upto the Lakshadweep Sea. Nitrogen cycle during the bloom season is being studied.

Carbon uptake by different size fractions of phytoplankton in northern Arabian Sea showed that about 20-25% of the biomass and production was contributed by picoplankton.

Further, chemosynthetic studies were also carried out in the region of primary and secondary nitrite maxima. In this area, ATP values varied from 0.005 to 409 µg/l, chl a from 0.02 to 0.2 µg/l and POC from 0.2 to 0.8 gC/m³.

In the northern Arabian Sea chl-a varied from 0.04 to 0.5 µg/l, ATP from 0.59 to 1.4 µg/l and POC from 0.21 to 0.87 g/m³ in the euphotic zone.

In the southwest Arabian Sea, chl-a, ATP, POC and primary production investigated showed that ATP concentration varied from 0.035 to 0.30 µg/l. Further localized patches of high and low productivity are being studied for their possible relationship with satellite and other remote sensing data.

b) Secondary Production:

Standing stock values in the coastal waters of Goa ranged from 22.81 to 53.65 mg C/m³ (x = 38.23 mgCm³). Zooplankton community was diverse and no single group dominated the zooplankton. Grazers formed the main component

of zooplankton population (85 to 96%). Zooplankton diversity increased with increase of carnivores in the ecosystem. Diversity values were higher at stations with lesser estuarine influence.

Zooplankton collected from Kavaratti Atoll showed nocturnal abundance of zooplankton. The average biomass values for night and day samples were 212, 152 ml/1000 m³ respectively. Copepods were the most dominant group followed by euphausiids, amphipods, decapod larvae, polychaete larvae, fish eggs and fish larvae. Copepod species belonging to the genera **Paracalanus**, **Eucalanus** and **P. labidocera** were most common. These species were abundant in zooplankton collections taken from the surrounding sea than in the lagoon of Kavaratti Atoll.

Karyological studies of 6 species of copepods viz: **Pontellopsis herdmani**, **Pontella princeps**, **Calanopia aurivilli**, **C. elliptica**, **C. minor** and **Pontella plumata** were carried out. The chromosomes number was found to be 20 diploid number in the former two and 22 diploid number in the latter four species. The Karyotype formulae comprised of 10 M + 10A in **Pontellopsis herdmani** and 16 M + 4 A in **Pontella princeps**: In males of all the species of **Calanopia**, the formulae were as 7 SM + 13 M + 2A in **C. aurivilli**, 5 SM + 14 M + 3 A in **C. elliptica** and 1 SM + 19 M + 2 A in **C. minor**. In **P. plumata** the females had 20M + 2 A chromosomes. A comparative study of all data on the species in family Pontellidae worked out from the Indian waters shows that genera **Labidocera**, **Pontella** and **Pontellopsis** are of rather recent origin from the more ancient **Pontella** and **Calanopia** genus.

c) Marine algae:

1) Marine algal survey with the help of scuba diving and remote sensing technique has been initiated. At present ground truth from the intertidal area is being collected from Mangalore, Honavar, Karwar, Baga, Anjuna, Malwan, Achra and Ratnagiri. So far 40 algal species have been collected with an average biomass of 1.25 kg/m². During the monsoon season **Porphyra vietnamensis**, **Ulva fasciata** and **Enteromorpha** sp. dominated, while during the rest of the season **Sargassum** sp. and **Gracilaria corticata** dominated. A new species of red alga **Coelosira** sp. was reported from Bambolim shore, Goa.

2) A survey was carried out on marine algal resources of the Seychelles coast at the request of Govt. of Seychelles. In all 71 algal species. 9 mangrove sp. and 6 seagrass sp. were reported.

d) Mangroves:

1) Experiments to study decomposition rates of **R. mucronata** showed that release of phosphate during the decomposition was gradual, increasing from an initial value of 0.04 µg-at P/l to attain a peak value of 0.47 µg-at P/l after five months. Nitrite increased from initial value of 0.56 µg-at N/l to 79.35 µg-at N/l after two months and subsequently decreased to about 0.9 µg-at N/l at the end of the experiment. The rapid increase in nitrite and its subsequent decrease is in conformity with its role as an intermediary product of nitrogen regeneration during decomposition.

2) Ecological studies of mangroves at Terekhol. Mandovi & Zuari estuary were completed. **Monostroma**, **Enteromorpha** & **Halophila** (Seagrass) were domi-

nant in the estuarine area. **Caloglossa** was observed growing on the pneumatophores.

e) **Benthos:**

1) **Deep Sea Benthos:**

Investigations on the organisms inhabiting the region of tremendous hydrostatic pressure in the abyssal depths (over 3500m) of central and southern part of the Indian Ocean (equator to 30°S latitude; 60-105°E longitude) were continued. Observations on the distribution, abundance and structural adaptations, revealed that the animal life at such great depths is diverse (43 species), rich (4310/m²) and productive (0.1 to 22.8²gm). A great variety of adaptive radiations in relevance to feeding, vision and protection are more evident in epifauna (constituted by finfishes and crustaceans belonging to 7 and 2 genera, respectively) than in the relatively abundant infauna.

2) **Community Metabolism of Intertidal Fauna:**

Energy production and transfer mechanism as deduced from standing crop estimates and organic carbon production in the sandy intertidal beaches, revealed that while the production varied from 2353.37 g/m²/yr to 1050.10 g/m²/yr, the organic carbon requirement also proportionately varied from 1765 gC/m²/yr to 785.5 gC/m²/yr, in an estuarine and an open sea beach, respectively. The effective energy transfer, between subtidal and intertidal biotope, takes place mainly through filter and suspension feeding organisms which contribute from 82 to 90%. Role of meiobenthic deposit feeders, in the energy transfer, was less than 10% and hence, insignificant. Mean grain size, sorting of the sediment and organic carbon content, showed significant correlation to the product ion and energetics of the beach fauna.

3) **Benthos of Coral Atolls:**

Increased surface area, increased habitat complexity and abundance of food, supported large and diverse population of benthic invertebrates in the Minicoy lagoon. Nine macrofaunal and ten meiofaunal taxa with population density of 494 - 2259/m² and 914 - 1864/ 10 cm respectively formed the benthos. Distribution and abundance of fauna was dependent on the density and biomass of the turtle grass. Abundance and diversity of benthic species increased with plant biomass and decreased with the distance away from the shore.

4) **Environmental Impact Assessment of Mining Activity on the Estuarine Benthos and Shellfisheries:**

Analysis of data collected over the last 10 years, revealed that in the Mandovi, Cumbarjua Canal and Zuari estuarine system of Goa, the following changes have taken place.

- (i) Population density of bottom living populations has decreased from 4233/m² in 1972-73 to 681/ m² in 1982-83.
- (ii) Exploitable resources of hard clam have declined from 1.8 kg/m² in 1972-73 to 0.128 kg/m² in 1982-83.
- (iii) Biomass production, in space and time, has declined by more than 18 limes. While in 1972-73, the annual mean biomass was 36.87 gm². the corresponding value for 1982-83. was only 2.09 gm².

- (iv) Community structure: Burrowing type of resident fauna of 1972-73 has been lost to the overwhelming, prevalence of epifaunal species. Major changes in the feeding types, from suspension or filter feeders to detritus or deposit feeders, were noticed.
- (v) Suspended solids: A three fold increase in the suspended solids was observed - annual range and annual mean which was 60.932 mg/l and 303 mg/l respectively in 1972-73, rose upto 720-902 mg/l and 900 mg/l respectively, in 1982-83.
- (vi) Sediment Type: sandy mud deposits of 1972-73 were observed to be covered by red clay and further blanketed by lateritic cobble and pebbles.

3.5.2 Coastal Zone Management (Coastal Aquaculture).

1) Edible Oysters.

Growth and reproduction of Giant Oyster, *Crassostrea graphoides* (Schlotheim), was studied in a running seawater circulating system. Use of specially made diet (dried seaweed powdered with fish meal and compounded with mineral additives) enhanced the growth, from 2 mm(dvd)/month in natural bed to 3.4 mm(dvd)/month. under partially controlled conditions. Preliminary results, of trials conducted on the effect of crude extracts of marine organisms on controlled spawning, are encouraging and are being repeated.

2) Shrimp culture:

Studies on selective breeding and hybridization in banana shrimp, *Penaeus merguensis*, De Man from Goa and Devgad (Maharashtra) waters, were under taken. Nineteen characters were studied. Average values for all morphometric characters were comparatively more in Devgad waters than the Goa region. Posterior abdominal circumference was strongly related to tail weight in the former region whereas it was the carapace length in the latter waters.

3) Induced Spawning in Mulletts:

In the experiments, while the spawning could be achieved within 24 hours after administering the hypophyseal extract, the embryonic and larval development was abortive — possibly because of high and fluctuating ambient temperatures. Further experimental work, under controlled temperature conditions, has revealed the survival upto 60%.

4) Feed Organisms:

Optimum conditions for growth and reproduction of laboratory reared nematodes, turbellarians and harpacticoid copepods are being worked out.

3.5.3 Marine microbiological studies in the seas around India.

Studies on marine bioluminescent bacteria were conducted during January-March, 1984. Luminescent bacteria were present in eight out of ten species of fish screened from waters off Aguada. They contributed 8-12% of the total viable count of bacteria from the seawater.

Over two hundred isolates for heterotrophic activities were obtained from Kavaratti region.

The number of coliforms was very high in the freshwater area and decreased drastically towards marine conditions in the Hooghly estuary.

During July-August, sediment samples collected from 1, 3 and 5 cm depth at Dias beach were analysed for sulfate reducing bacteria and sulfate reducing activity (SRA). The SRA determined directly using slurries showed values upto 990 nMS =/g/24 hr at 5 cm depth. About 105, **Thiobacillus denitrificans** like organisms, collected from off Goa and Bombay were tested for their S.O. oxidation and chemolithotrophic aerobic and anaerobic production. Most of them were facultative anaerobes. About 25% of them could oxidise S.O. to an extent of 5-10% acrobically and 20.2% could oxidize to the same extent anorobically.

Different beaches of Goa (Anjuna, Baga, Cabo Kaj Nivas and Dias) were examined at monthly intervals for pathogens in intertidal algae. In a species of green alga, **Cladophora** sp. one more phycomycetous fungus namely **Olpidium** sp. was found to occur consistently besides the two **Cladochytrium** sp. and **Sirolopidium** sp. in other species of the same alga reported last year. In addition, a species of **Labyrinthula** sp. was always found as saprophyte in dead and decayed cells. A **Chytridium** species was found on a red alga **Centroceras** sp. Phytoplankton samples from tidal rockpools showed no true pathogens. **Rhizoclonium** sp. the green alga, collected from the lagoon of Kavaratti Island was found infected with **Cladochytrium** sp. and **Labyrinthula** sp. Culturing of these algae and their pathogens under laboratory conditions is carried out intensively.

Work on the little known marine protists, the thraustochytrids was continued from the lagoon of Kavaratti Island. Upto 13000 thraustochytrids per litre of water were found. This is the highest number ever reported for these organisms in any water in the world. This high density of occurrence indicates its possible significant role in the coral reef ecology. Effect of salinity on the growth of thraustochytrids in solid, liquid and seawater with pine pollen was studied. Lignicolous marine fungi were isolated from wooden panels including those treated with copper-brom arsenate. **Humicola allopallonella** was the most common species on the treated panels.

Biological investigations in Antarctica

a) Antarctic Benthos:

Samples of benthos collected during II and III Indian Scientific Expeditions to Antarctica were studied for the distribution, abundance and trophism of fauna during austral summer. The coastal waters, including **polynya**, show a dense standing crop (average 500 gm²) mainly contributed by siliceous sponges. While the biomass (mean 1.2 gm) decreased, at depths more than 1000 m and upto 3000m, the fauna became many times more diverse than in the coastal waters.

Phytoplankton was studied on III Antarctic Expedition in the southern sea from 70°S 11°E to 33°S 52°E in summer. The studies included ATP, POC and chl a as well as primary productivity using simulated in situ incubations. Primary production in the marine environment ranged from 0.3g/C/m²/ day to 8.3 gC/m²/day. Chl a ranged from 0.2 to 7.8 mg/m³ and ATP from 0.2 to 4.6 mg/m³. Samples were collected in the lakes of the Schumoihar oasis. Although Chl a in the water column of the freshwater lakes was low as was productivity, benthic algae belonging to the genus **Phomidium** make the lakes very productive.

b) Marine algae at Antarctica:

i) At Davis, ANARE (Antarctica) 30 marine algal sp., 24 animal taxa associated with marine algae: 15 lichen sp., 5 moss sp. and two freshwater algal

spp. have been recorded. The average annual algal yield was estimated to be 1.34 kg/m².

ii) The experiment on the chromatic adaptation of Antarctic marine algae to various light intensity and temperature revealed that some species required more than 24 hrs to alter their pigment concentrations in certain light intensities. Experiment showed that temperature upto + 20°C is favourable only to **Porphyra endiviifolium** while other species studied showed detrimental effects on photosynthetic pigment concentrations and the algal thallus as a whole after exposure to temperature above +12°C.

iii) Studies on animals associated with Antarctic marine algae showed that species such as **Paramoera walkeri**, **polychaetes**, **nematodes**, **Cymodoella tubicauda** showed preference to certain algal species with the season. Maximum number of animal species were recorded from the thallus of **phyllophora antarctica** followed by **Palmaria decipiens**. The holdfast of **Himantothallus grandifolius** and **Desmarestia menziesii** showed highest number of animal species with nematodes dominating.

B. SPONSORED PROJECTS

Details of work carried out are given under chapter on "Sponsored/Grant-in-aid Projects".

3.6

Biofouling and Corrosion Studies

3.6.1 Studies on marine fouling, wood preservation and corrosion along the Indian coast.

A. R & D PROJECT

a) Biofouling:

The studies on biofouling in the estuarine region of Goa are being continued at three stations in Zuari estuary viz. Cortalim, Goa Shipyard and Oil jetty in the Mormugao Harbour. The data is being collected with regard to aluminium panels and recently fibre glass panels are also being exposed. The aluminium panels exposed so far are of two types viz. monthly and cyclic.

In order to establish the usefulness of the fouling organisms as indicator species of environmental deterioration, data has been collected on bioaccumulation of trace metals such as Cu, Ni, Zn, Co, Mn and Fe in sessile barnacles which form a major component of fouling community in Zuari estuary. The results obtained (TABLE I) clearly establish that sessile barnacles could be used as indicators of accumulation of trace metals in the environment.

TABLE I

Metal content in the individuals of *Balanus emaryllis*.

Metal	Mean metal concentration (μ moles g ⁻¹ dry wt.)	CV. (%)	gl	Skewness Significance (p)
Copper	1.43	51.72	8.87	<< 0.001
Zinc	7.46	51.73	1.99	<< 0.001
Iron	76.94	38.26	1.12	<< 0.01
Cobalt	10.56	66.24	0.72	ns
Manganese	1.25	61.88	0.57	ns
Nickel	1.82	39.14	0.39	ns

These studies have also been extended to Kakinada along the east coast and to Lakshadweep Islands. At Kakinada, data has been collected on fouling organisms settled on a marker buoy over a period of about four months. It mainly comprised of stalked barnacles (**Lepas** sp.). Panels in Lakshadweep as well



Biofouling on Aluminium panel (cyclic) in Zuari Estuary.



Settlement of foulers on the buoy in Kakinada waters



Corrosion of mild steel (left) and Aluminium panels (right) in offshore waters of the Arabian Sea

as in Antarctic waters have been exposed in May, 1984. The results at both the places are still awaited.

Investigations on the biochemistry of water samples, suspended matter as well as surficial sediments have been initiated so as to collect information on the calorific value of food matter that could be available to fouling organisms. It would help initially in assessing the rate of growth of fouling organisms. These investigations are being carried out in the estuarine region as well as in off-shore areas of the Arabian Sea and Bay of Bengal. The sampling for these studies could be done in the Bay of Bengal during the scientific cruise No. 143 of RV **Gaveshani** in Oct - Nov '84. The analysis of samples indicated that the lipid concentrations of surficial sediments varied from 157 to 972 $\mu\text{g/g}$ of which polar lipids formed the major fraction (68%) as revealed by silica-alumina column chromatography.

Data on biofouling from ORV **Sagar Kanya** was also collected during the vessel's dry-docking in Bombay. From the data the increase in frictional resistance is being calculated. It would enable to estimate the increase in consumption of fuel for the ship.

b) Corrosion Studies:

The data collection on rate of corrosion of mild steel and aluminium in the estuarine region of Zuari is being continued. These investigations have been extended to the off-shore region in the Arabian Sea. This is for the first time in India that such data is being collected upto the depth of 60-65 m. A set of panels is changed every month whereas the other set is kept for a longer duration extending upto six months and more. The rate of corrosion of m.s. panels as assessed from monthly panels varies from 1.32 mpy to 34.10 mpy at 2 m. depth whereas at 60 m. depth the figures for the corresponding months are 1.95 mpy and 20.07 mpy. In case of aluminium the maximum rate of corrosion at 2 m. depth was found to be 3.98 mpy whereas minimum was 0.72. The corresponding figures for 60 m. depth were 5.97 and 0.59 mpv.

c) Studies on wood-boring:

These studies are being continued in the estuarine region and have been extended to the off-shore region as well. The observations revealed that timber destruction in off-shore waters was caused only by Teredinid forms and so far no **Pholadios** have been found. The species so far recorded comprise of **Bankia campanellata**, **B. carinata**, **B. rochi**, **Teredo mindanensis**, **T. furcifera**, **T. somersi** and **Lyrodus pedicellatus**. Of these, **Teredo mindanensis** is a new record for Indian waters.

B. SPONSORED PROJECT

Details of work carried out are given under chapter on "Sponsored/Grant-in-aid Projects".

3.7

Ocean Engineering

1.7.1 Engineering studies related to coastal and offshore development.

A. R & D PROJECT

3.7.1 Engineering studies related to coastal and offshore development.

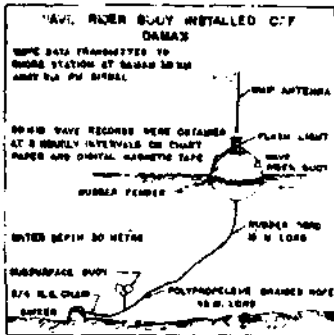
1. Development of mooring, deployment and retrieval techniques:

Suitable mooring systems for installing Datawell Wave rider buoys were designed for depths upto 100m to withstand different sea conditions off the east and west coasts of India. Using these moorings which were fabricated in the field stations, as per the design, wave rider buoys were deployed successfully off Bombay High, Yanam and Uran. A mechanised boat of about 15 meter length with winch capacity of about 2 tonnes, was used for deployment and retrieval of wave rider buoy off Uran in the South-west monsoon period.

Some useful literature survey has been done and technical requirements and methodology for the development of deep sea instrumented moorings for depths upto 5000 m for the proposed environmental data collection programme on polymetallic nodules project at NIO have been formulated.

Wave data collection programme off Yanam (May 83 - August 84), Machilipatnam (May 83 - Dec. 83), Uran (June 84 to Oct. 84) and Bombay High (May 83 - Nov. 84) for ONGC, was successfully completed and the data are being analysed using Tucker's zero-upcrossing and spectral methods. Sample results are presented in the table 1.

The cyclonic storm which hit the Gujarat coast on 8 November, 1982 had a wind speed of 170 to 180 km per hour and a maximum wave height of 8.15 m with associated wave period of 10 sec. The corresponding maximum significant wave height at the time was 5.97m. The zero crossing wave periods ranged between 5 sec and 7.5 sec.



GROWTH AND DECAY OF WAVE SPECTRA DURING NOVEMBER - 1982 CYCLONE OFF GUJARAT

VARIATION OF CERTAIN WAVE PARAMETERS CYCLONE PERIOD

NO. OF	DATE	TIME	SEA WAVE HEIGHT (m)	SEA WAVE PERIOD (s)	SEA WAVE DIRECTION (deg)	SPECTRAL PEAK PERIOD (s)	PERCENT SPECTRAL PEAK
1	11.11.82	0800 HRS	0.45	5.50	070	5.70	0.20
2	"	0810 HRS	0.70	5.00	060	5.00	0.20
3	"	0820 HRS	0.90	4.00	150	4.00	0.20
4	"	0830 HRS	0.90	3.50	150	3.50	0.20
5	"	1800 HRS	0.75	7.00	070	7.00	0.20
6	"	1810 HRS	0.80	6.00	070	6.00	0.20
7	"	1820 HRS	0.70	5.50	070	5.50	0.20
8	"	1830 HRS	0.80	5.00	070	5.00	0.20
9	"	1840 HRS	0.80	5.00	070	5.00	0.20
10	"	1850 HRS	0.80	5.00	070	5.00	0.20
11	"	1900 HRS	0.80	5.00	070	5.00	0.20
12	"	1910 HRS	0.80	5.00	070	5.00	0.20
13	"	1920 HRS	0.80	5.00	070	5.00	0.20
14	"	1930 HRS	0.80	5.00	070	5.00	0.20
15	"	1940 HRS	0.80	5.00	070	5.00	0.20
16	"	1950 HRS	0.80	5.00	070	5.00	0.20
17	"	2000 HRS	0.80	5.00	070	5.00	0.20
18	"	2010 HRS	0.80	5.00	070	5.00	0.20
19	"	2020 HRS	0.80	5.00	070	5.00	0.20
20	"	2030 HRS	0.80	5.00	070	5.00	0.20
21	"	2040 HRS	0.80	5.00	070	5.00	0.20
22	"	2050 HRS	0.80	5.00	070	5.00	0.20
23	"	2100 HRS	0.80	5.00	070	5.00	0.20
24	"	2110 HRS	0.80	5.00	070	5.00	0.20
25	"	2120 HRS	0.80	5.00	070	5.00	0.20
26	"	2130 HRS	0.80	5.00	070	5.00	0.20
27	"	2140 HRS	0.80	5.00	070	5.00	0.20
28	"	2150 HRS	0.80	5.00	070	5.00	0.20
29	"	2200 HRS	0.80	5.00	070	5.00	0.20
30	"	2210 HRS	0.80	5.00	070	5.00	0.20
31	"	2220 HRS	0.80	5.00	070	5.00	0.20
32	"	2230 HRS	0.80	5.00	070	5.00	0.20
33	"	2240 HRS	0.80	5.00	070	5.00	0.20
34	"	2250 HRS	0.80	5.00	070	5.00	0.20
35	"	2300 HRS	0.80	5.00	070	5.00	0.20
36	"	2310 HRS	0.80	5.00	070	5.00	0.20
37	"	2320 HRS	0.80	5.00	070	5.00	0.20
38	"	2330 HRS	0.80	5.00	070	5.00	0.20
39	"	2340 HRS	0.80	5.00	070	5.00	0.20
40	"	2350 HRS	0.80	5.00	070	5.00	0.20

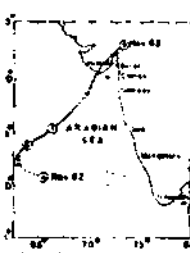
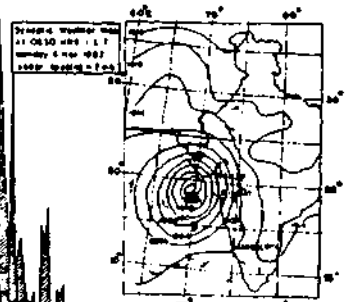
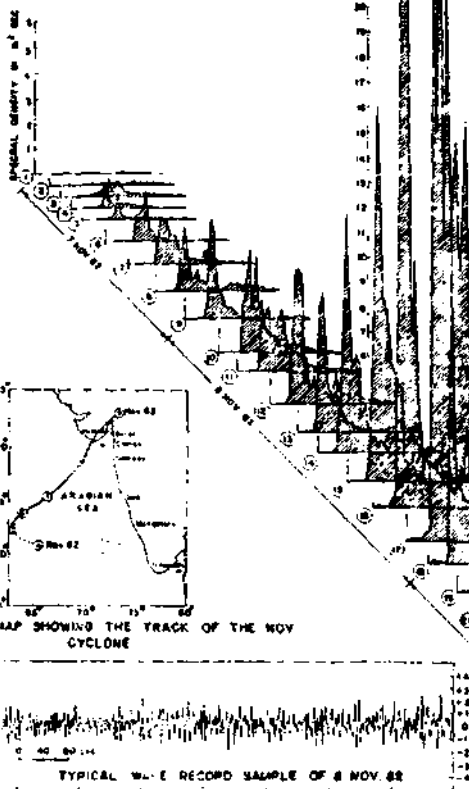


Fig. 8

2. Long-term data collection programme.

Under the time series data collection programme on waves along the Indian coast, the data were collected off Machilipatnam, Yanam, Uran and at Bombay High.

a) Off Yanam:

A wave rider buoy was deployed at 88m depth off Yanam in the Godavari Basin and a wave receiving/recording station was operated at a coastal village "Pedagadimoga" close to the shore. Twenty minutes wave records were obtained every 3 hours both on the chart paper as well as on the digital magnetic tapes upto August 1984.

b) Uran:

A wave rider buoy was deployed at 10 meter depth off Dharmtar Creek and a wave recording station installed in the ONGC guest house at Uran. Twenty minutes wave records were obtained at every 3 hours interval on the chart paper and digital magnetic cassettes from June, 1984 to October, 1984.

c) Bombay High:

A wave rider buoy was moored at 75m depth at Bombay High and a wave receiving/recording station was operated on the offshore drilling platform viz. **Segarpragathi**. The 20 minutes wave records were obtained every 3 hours both on the chart paper as well as on the digital magnetic tapes from May 1983 to November 1984.

d) Collection of weather data:

An Aanderaa weather station (self recording type) was installed at Yanam, near Kakinada from January 1984 to November 1984. Time series data on wind speed, wind direction, air temperature radiation, humidity, rainfall, etc. were recorded at hourly intervals.

3. Data analysis and results.

The digital wave records obtained on cassette tapes were analysed using the sophisticated software package "NEPTUN" at DEC-10 computer of the TIFR, Bombay. The ABC-80 Micro-computer system procured under NORAD Assistance programme was also used for analysing wave and surface meteorological data. Zero-crossing and spectral methods were used for obtaining various wave parameters.

TABLE 1: Month-wise variations of Hs, Hmax & Tz

Place and Date	Zero upcrossing method			Tucker's method		
	Hs (m)	Hmax (m)	Tz (sec)	Hs (m)	Hmax (m)	Tz (sec)
1	2	3	4	5	6	7
1. Yanam						
Jan. 84	0.52	0.63	4.78	0.31	0.60	4.48
	to	to	to	to	to	to
	1.27	1.78	9.57	1.46	2.40	16.67

	1	2	3	4	5	6	7
Feb.		0.50	0.65	4.21	0.28	0.45	4.71
		to	to	to	to	to	to
		137	2.00	5:81	2.47	3.95	12.24
Mar.		(Digital data faulty)			0.41	0.55	4.62
					to	to	to
					1.02	1.50	13.64
April		0.40	0.52	3.16	0.34	0.50	3.65
		to to		to	to	to	to
		132	1.63	6.39	1.06	1.65	12.53
May 0.95			1.31	4.61	0.96	1.20	4.46
		to	to	to	to	to	to
		2.49	3.80	7.08	2.55	4.20	8.82
June		1.03	1.15	4.13	0.86	1.30	4.85
		to	to	to	to	to	to
		2.67	3.37	7.18	2.10	3.25	8.70
July 0.79			0.96	4.40	0.64	0.90	4.80
		to to		to	to	to	to
		2.39	3.32	8.96	2.33	3.75	13.04
Aug 1.02			1.42	4.62	0.82	1.20	5.36
		to	to	to	to	to	to
		2.98	3.84	8.77	2.80	4.10	16.88
2. Bombay High							
Feb. 84		0.47	0.60	4.14	0.63	1.22	3.79
		to	to	to	to	to	to
		1.87	2.85	12.50	2.02	3.80	6.67
Mar.		0.70	1.06	3.69	0.62	0.70	4.08
		to	to	to	to	to	to
		1.22	2.16	4.75	2.04	1.65	11.65
Apr.		0.58	0.85	3.77	0.48	0.60	4.03
		to	to	to	to	to	to
		1.74	2.72	9.84	1.85	2.75	16.67
May		0.93	1.60	4.14	0.93	1.25	5.13
		to	to	to	to	to	to
		3.95	5.08	6.74	1.77	3.00	7.89
June		3.82	4.57	6.67	2.61	2.80	6.00
		to	to	to	to	to	to
		4.66	7.61	8.23	4.76	7.87	9.52
July (Digital data faulty)					2.80	4.30	7.50
					to	to	to
					3.95	6.40	9.38
3. Uran							
June (Digital data faulty)					0.40	0.60	5.11
					to	to	to
					2.08	2.50	10.43

	1	2	3	4	5	6	7
July		1.84	2.09	3.97	0.63	0.80	6.32
		to	to	to	to	to	to
		3.10	3.45	9.77	2.38	3.90	13.46
		(one week data)					
Aug.		0.60	1.96	3.56	0.45	0.60	5.66
		to	to	to	to	to	to
		3.21	3.63	9.03	2.28	3.82	18.46
		(Two weeks' data)					
Sept.		(Digital data faulty)			0.62	0.90	5.02
				to	to	to	
				1.83	3.08	8.76	
Oct.		(Digital data faulty)			0.25	0.30	4.76
				to	to	to	
				1.14	1.75	16.44	

4. Coastal engineering studies.

The shallow water numerical wave refraction was carried out for the coast near Goa and Visakhapatnam in order to understand and evaluate the coastal processes in those areas.

The analytical model developed for studying the shoreline changes caused due to construction of a shore connected breakwater was modified with finite difference scheme. This model was tested successfully by applying to Visakhapatnam coastline to study the shoreline changes due to the construction of breakwaters.

5. Wave hindcast and storm surge models.

The software packages for storm surge model 'DUCHESS' and wave hindcasting model 'DOLPHIN' have been procured from Delft Institute of Technology, Netherlands under the ongoing NORAD assistance programme. An extensive field programme on water level observations in shallow as well as deep waters has been planned for the Bay of Bengal for calibrating the storm surge model.

Weather charts and relevant wind information on various storm/cyclones which occurred during the last 15 years are being collected from IMD, Pune and preparation of data input on magnetic tapes to the models DUCHESS and DOLPHIN is under progress.

Two NIO Scientists who have recently completed training on the sophisticated computer models DUCHESS and DOLPHIN at Delft Institute of Technology, Netherlands and Norway under the NORAD assistance programme are implementing these models on ND 520 computer at NIO.

B. SPONSORED PROJECTS

Details of work carried out are given under chapter on "Sponsored/Grant-in-aid Projects".

3.8

Marine Instrumentation and Computer

3.8.1 Development of marine instrumentation systems.

3.8.2 Development of multiparameter buoys.

The Computer Centre was merged with the Marine Instrumentation Division in April, 1984 and the new Division has been renamed as Marine Instrumentation and Computer Division.

The new division is responsible for the maintenance and running of the computers of the Institute as well as on board the oceanographic research vessels managed/owned by the Institute, besides its normal R & D activities.

The Marine Instrumentation Group is involved in the design, development and fabrication of marine instruments used in the Institute, as well as for general oceanographic work. The two on-going R & D projects of this Group, and their activities in the Division are given below.

The other responsibilities of the Division are the management of the following infrastructural services and facilities:

- * Computer Centre
- * Workshop
- * Drawing Section
- * Photography Section
- * Prototype Section

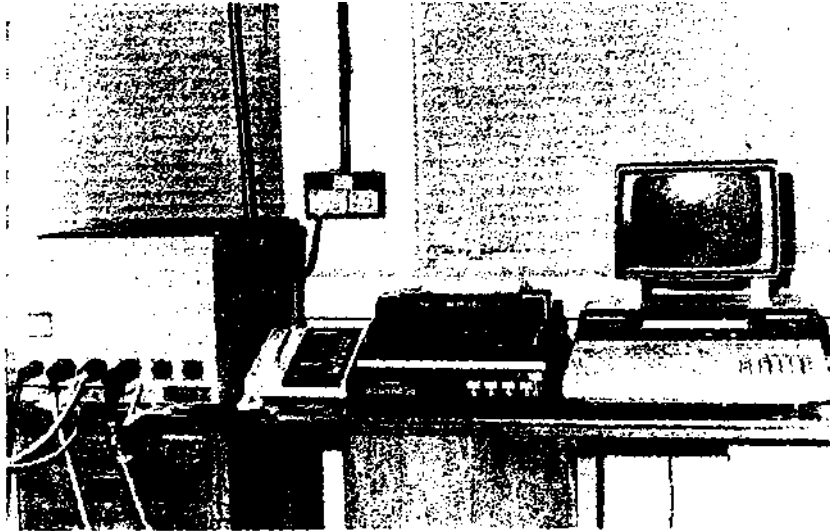
A. R & D PROJECTS

3.8.1 Development of Marine Instrumentation systems.

a) Data transmission via Satellite:

The Division has developed a facility to transmit oceanographic data collected by RV **Sagar Kanya** to a ship laboratory using the maritime satellite, **INTELSAT V**, of the **INMARSAT** system, positioned at 63 degrees East above the equator.

This facility will enable the analysis of all types of data collected by the vessel on a near-real time basis. Adaptive vessel movement is therefore one of the possible uses of such a data transmission facility. The satellite communication terminals at the ship laboratory as also on board the Research Vessels are interfaced to computers at both ends of the satellite link and this configuration ensures near error-free data reception at 2400 baud rate. The set-up is shown in Photograph.



System for Data transmission via satellite.

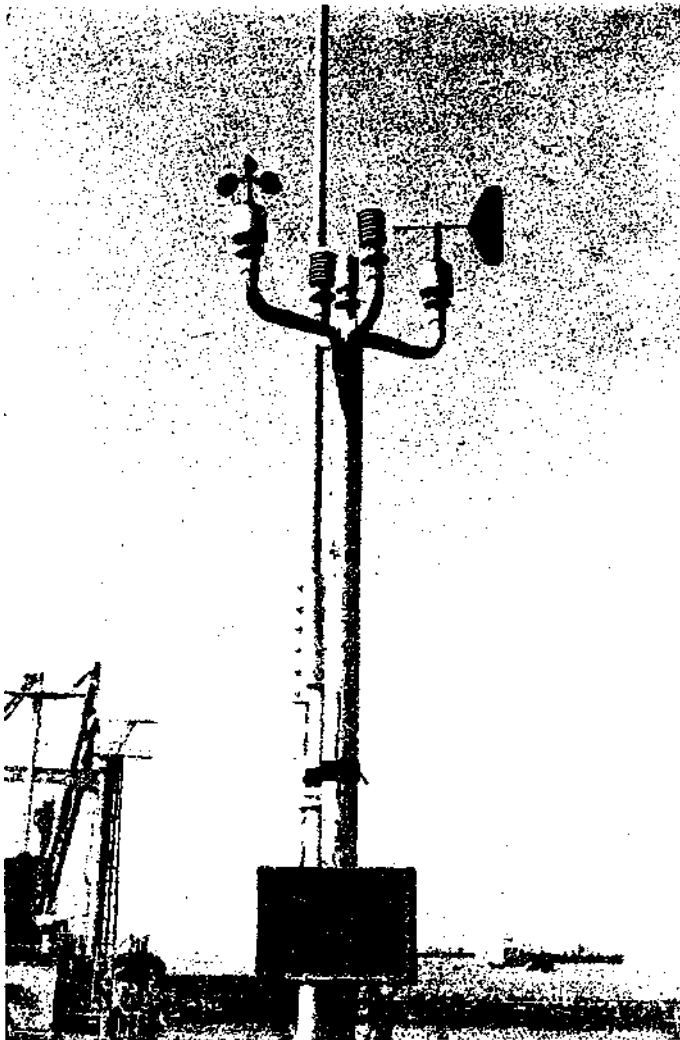
b) Weather Station.

The design, fabrication and installation of a weather station on-board RV **Gaveshani** was taken up to facilitate ground truth measurement for remotely sensed satellite data. The following parameters were measured every 10 secs for 10 minutes, and the data stored on a 1/4" tape of a micro-cassette recorder:

- * wind speed
- * wind direction
- * air temperature
- * relative humidity
- * sea-surface temperature
- * barometric pressure
- * internal references
- * ship's heading — manual entry

The instrument is designed around the **INTEL 8086** -16 bit microprocessor. Each set of parameters is sampled every 10 secs., computed and stored on tape. Data can also be read from built-in front panel LEDs. The instrument was installed on board RV **Gaveshani** and was used on two cruises during Dec 84.

Data collected by the weather station was transferred to both APPLE-II personal computer and the MDS-236, Microprocessor Development System. The weather station mast has been installed on the instruments platform adjacent to the basement to collect data for monitoring the long term performance of the instrument.



Weather station on board R. V. Gaveshani

c) Maximum Depth Indicator:

This work has been started recently on a user requirement. The indicator will be attached to any profiling under-water instrument and the maximum depth to which the profiling instrument has been lowered will be measured and this depth reading will be stored and displayed when the instrument is retrieved. The maximum depth of operation will be recorded irrespective of the cable length and the present position of the instrument.

3.8.2 Development of Multi-Parameter Buoys.

With the expertise gained in the design & development of a data buoy which was deployed off Mormugao Harbour, the design and development of a wave following data buoy with a satellite link for on-line data transmission has been initiated during 1984.

The parameters to be measured are:-

- * wind speed
- * wind direction
- * air temperature
- * barometric pressure
- * buoy heading
- * sea surface temperature
- * wave period
- * wave height
- * wave direction

A detailed literature survey on existing buoy systems has been concluded and has enabled the selection of the relevant parameters to be incorporated in the design.

Platform Transmitting Terminals (P.T.T.s) will be used for the transmission of the data to shore.

B. SPONSORED PROJECTS

Details of work carried out are given under chapter on "Sponsored/Grant-in-aid Projects".

3.9

Information, Publication & Data

During April, 1984 the activities of the erstwhile Planning and Data Division were reorganised. The Planning section and Training Centre formed Planning and Training Division while the Computer was merged with the Marine instrumentation Division. The rest of the activities were regrouped under Information, Publication and Data Division.

The various activities undertaken by the Division are as follows:

a) **Publication**

The regular publications of the Institute viz. **Mahasagar**-Bulletin of the National Institute of Oceanography and **NIO Newsletter** were brought out and the Division was successful in clearing back log, making the journal up-to-date. The Editorial Board of **Mahasagar** was reconstituted during the year. It now contains 13 members — experts in different disciplines of Marine Sciences.

"Collected Reprints" of the year 1981 and 1982 were compiled. Reprints for 1983 are under compilation.

Seventeen Cruise Reports and two Annual Cruise Reports of **RV Gaveshani** were published for restricted distribution. In addition to cruise reports of **RV Gaveshani**, at the request of the Department of Ocean Development, Government of India, the cruise reports of **ORV Sagar Kanya** were also brought out on the lines of **Gaveshani** reports. Accordingly four reports of Sagar Kanya cruises have so far been completed and released.

Annual Report of the Institute for the year 1983 was compiled, printed and released.

b) **Information**

A computerised bibliography on aquaculture was released. This contains 3000 references on pisces, crustacea, mollusca and general fishery.

An annotated bibliography containing the research papers published by NIO scientists and another on "Energy from the Sea" from the references available in the NIO library have been compiled.

The Information brochures on NIO, **RV Gaveshani**, **ORV Sagar Kanya** and Sponsored Projects of NIO have been updated and printed.

The revision and updating of Directories on Marine Scientists and Research Projects have been initiated. The response from other institutes has been very-encouraging.

The Information group organised NIO Pavilion in Trade and Industries Fair at Pune in April-May, 1984 and NIO's display in CSIR Pavilion in India International Trade Fair at New Delhi in November, 1984. The group also played a key

role in the display of NIO activities which were shown to the Vice-President of India. Large number of visitors including VIPs, Research Scholars and students keep visiting the Institute and they were attended to, shown and explained the activities in person while a large number of queries on similar lines were replied sending them the literature.



Dr. S. Varadarajan, DGSIR, looking at the NIO exhibits in the CSIR Pavilion of the India International Trade Fair at New Delhi.

During 20-28 January, 1985 a young oceanographer's convention was organised at NIO in collaboration with Bal Bhavan Society, New Delhi. The programme was inaugurated by Dr. Gopal Singh, Lt. Governor of Goa, Daman & Diu. In this programme about 48 students (age group 13-16) from various parts of the country were exposed to the oceanographic work at the laboratory and on the ship. They were explained the purpose and significance of the oceanographic research and work done.

c) **Indian National Oceanographic Data Centre (INODC)**

The INODC continued its activities towards management of oceanographic data and information. A brief account is given below.

The INODC was chosen by UNESCO as a venue for execution of UNESCO's Pilot Project with the following aims and objectives:

1. To develop software for the management of data and information at the national level.
2. To develop an effective and integrated information system including bibliographic services.
3. To improve technical information services.
4. To train the staff in data and information management.

Under this project, the UNESCO provided a mini-computer Rainbow 100B and the services of four consultants namely Mr. James Crease, Dr. Paul Geerders, Dr. W. Koch and Mr. W. Wild. These experts worked at INODC for different lengths of time. The following work was accomplished.

- i. Development of unified inventory and data base consisting of station, underway, time series and satellite data.
- ii. Development of formats for various categories of data.
- iii. Development of 15 software programmes for implementation of latest physical oceanographic algorithms.
- iv. Installation of Rainbow 100B and its interphasing with NIO's computer TDC-316 through a communication software package to allow two way data transfer.
- v. A set of programmes for INODC information system containing ROSCOP form, Input Station, Input leg, Method file, Tools file, Pass words and abbreviations file.
- vi. Development of a "Modular Documentation System" for information processing on TDC-316. Unfortunately due to some technical reasons this could not be made fully operational.

Other activities of INODC accomplished during the year are:

Data Acquisition

The following data sets were acquired:

- i. CTD data having 700 records from 35 stations covered during cruises

- of ORV **Sagar Kenya**.
- ii. GEOSECS data of 161 stations from Scripps Institute of Oceanography. U.S.A. This contains CTD and hydrographic data from Indian, Pacific and Atlantic Oceans.
 - iii. Summer MONEX Level — II B data containing satellite derived upper winds, Bathy & Tesac reports, Rainfall, Radiation and Rocket-sonde. Radiometer sonde and Radar observations from India Meteorological Department, Pune.
 - iv. Hydrographical data (1600 records) of eight RV **Gaveshani** cruises covering **149 stations**.

Data Processing

The corrections for temperature and depth in data of 14 **Gaveshani** cruises were made using the programme developed last year. This programme was converted in BASIC language also. A file containing the constants of all the thermometers was created for temperature corrections. Information from 10 cruises has been coded in the station inventory format. The work connected with creation of the biological data base has been initiated and more than 4000 records have been stored on magnetic media.

A readymade table for reading new salinity at 27°C from conductivity ratio between 0.01 to 1.12 at an interval of 0.0001 has been prepared and distributed to all the concerned organisations and agencies in the country. This will facilitate the scientists for immediate conversion of salinity.

During the year the following six computer programmes were developed:

- i. Two programmes for computing physical and chemical parameters at standard depths.
- ii. A programme for calculating Richardson number.
- iii. Two programmes for editing the IIOE data,
- iv. A programme for editing and retrieval of station Inventory data.

Data Dissemination

More than 30 enquiries were received from various universities, research organisations and other private agencies. The demand pertains to physical, chemical and biological data. The available data were supplied to them in various media. In addition research scholars were provided facility to copy down the data required by them.

3.10

Planning and Training

This new Division was formed in April, 1984. The following was the work done since its inception:

a) Training programme:

Efforts were made to procure the infrastructural facilities to build up a cell to develop trained manpower in ocean science and technology. As a part of the Thrust Area Project (Training Programme), nine postgraduate students from the Birla Institute of Technology and Science, Pilani were exposed to various branches of oceanography through invited lectures on a 6 week programme. They were also assigned specific project work at different divisions. Their progress was monitored through periodical tests. The programme concluded with the preparation of detailed work reports by the trainees and the evaluation of the reports by experts.

Realising the need of computer programming capabilities to be mastered by the working scientists, two 2-week long inhouse courses on FORTRAN IV programming in July and October, 1984, and one 1-week inhouse course on BASIC in March, 1985 were organised. Over a hundred Scientists were benefited by these courses. The classes were conducted by the computer experts available in the Institute.

To prepare the field scientists to meet exigencies of the sea, two 1-month long training courses on Survival Swimming were also organised. A total number of 78 scientists, including 11 lady scientists were trained in survival swimming manoeuvres by the end of these two training programmes.



Demonstrations by Scientists (Ladies) on conclusion of the Training in Survival Swimming.



Demonstrations by Scientists on conclusion of the Training in Survival Swimming.



Mrs. Varadachari giving the certificate to one of the participants of 'Survival Swimming Course'.

Presently preparations are being made to prepare syllabus and to build up the infrastructure for the training courses on marine sciences for the new entrants, DOD Research Fellows/Associates and the like.

b) **Planning:**

The planning group continued its activities of project formulation, budgeting, monitoring, costing and evaluation. The group also attended to the work on patents, technical utilisation and liaison with CSIR and industries from time to time. The Annual Plan Budget for 1985-86 and the draft Seventh Five Year Plan for Ocean Science and Technology were also prepared by this group.

The revised document of the Institute for the Seventh Five Year Plan was prepared in the new format where in the proposed activities of the Institute for 1985-90 were presented under three sub areas namely environment, living resources and non-living resources. Besides taking up new activities in the Seventh Five Year Plan, it is proposed to open new regional centres at Port Blair, Madras, Gujarat & Calcutta and to strengthen the existing infrastructure at the Headquarters and the existing regional centres. A total plan outlay of Rs. 18.24 crores is proposed for 1985-86.

In order to be more realistic, the ongoing projects were regrouped into 12 projects which include one multiagency project, two thrust projects and 9 major projects. The scientific and technical manpower was redeployed in these 12 projects keeping in view that scientists are not involved in more than two projects.

The Annual Plan documents of the Institute comprising of various activities proposed during 1984-85 and 1985-86 along with deployment of manpower and requirements of financial resources were prepared and sent to CSIR for sanction.

The expenditure for all projects was compiled for 1983-84 under two heads-direct and indirect expenditure. These expenditure statements helped very much in allotment of funds for the year 1984-85 and monitoring.

The technical information regarding sponsored projects, grant-in-aid projects, international projects and consultancy projects was compiled and computerised.

A close liason was maintained with Planning Division. Technology Utilization Division, Patent Unit and Manpower Division of CSIR Head quarters. The information on technical know how and other activities were communicated to polytechnic centres of the CSIR.

4

Regional Centres

4.1 Regional Centre, Cochin

4.2 Regional Centre, Bombay

4.3 Regional Centre, Waltair

4.1 Regional Centre, Cochin

A. R & D PROJECTS

1. Assessment and evaluation of biological resources of the seas around India.

IIOE, R.V. Gaveshani and O.R.V. Sagar Kanya collections:

In four cruises of RV **Gaveshani** (Cr. Nos. 130, 132, 139 and 140) a total number of 142 zooplankton samples were collected from 120 stations, during the pre-upwelling, upwelling and southwest monsoon seasons, using HT and Bongo nets with 200 and 300 micron meshes. The area covered during these 4 cruises include Visakhapatnam to Madras. Cochin to Bombay. Cape Comorin to Mormugao and Mormugao to Calcutta.

a) Foraminifera:

Fifty two species of recent foraminifera have been identified from sediment samples collected from the inshore waters of Trivandrum. Based on relative abundance of species it was observed that along the coast near the shore region up to 5 m depth is dominated by **Asterorotalia dentata** and others in lesser abundance being **Elphidium advenum** and **Amphistegina radiata**, whereas in the off-shore region (10 - 20 m) there was a change in species composition of the fauna, the most abundant form being **Ammonia beccarii** (Linne) **tepida**. Other species were **Operculina ammonoides**, **Nonion asterizans** and **Hanzawin concentrica**.

b) Copepoda:

The study on the systematics and distribution of the family Corycaeidae in the Indian Ocean showed that 84% of the samples was represented by the subgenus **Agetus** which consisted of 3 species, **Corycaeus** (**Agetus**) **typicus**, **Corycaeus** (**Agetus**) **flaccus** and **Corycaeus** (**Agetus**) **limbatus**. They were distributed all over the Indian Ocean with greater representation on either side of the equator. From the fifty collections made between Mormugao and Kenya, using multiple and HT nets. 5 species of **Corycaeus** have been identified, namely, **Corycaeus** (**Urocorycaeus**) **lantus**, **Corycaeus** (**Urocorycaeus**) **furcifer**, **Corycaeus** (**Agetus**) **typicus**, **Corycaeus** (**Corycaeus**) **danae** and **Corycaeus** (**Corycaeus**) **spaciosus**.

Observation on the ecology and zoogeography of the species **Scolecithrix danae** in the Indian Ocean indicated that this was the most abundant species (60%) of the family Scolecithricidae representing in 82% of the total stations of the IIOE. This species was recorded throughout the epipelagic zone of the Indian Ocean, north of 40°S with minimum occurrence in the equatorial waters especially along the African coast.

In the equatorial waters between India and Kenya from depths between 0 - 200 m the copepods **Canthocalanus pauper**, **Eucalanus sp.**, **Rhincalanus sp.** were abundant. Compared to the copepods of the Arabian Sea, these samples showed higher abundance of **Eucalanus mucronatus**, **Cosmocalanus darwini**, **Neocalanus gracilis**, **Actidius armatus** and **Metridia lucens**.

Observations on the diversity of copepoda in the areas Gulf of Oman, Gulf of Aden, head of Bay of Bengal, Malayan region, the southern Indian Ocean, the area around South Africa and southwest Australia showed high sp. diversity of **Calanus** and **Neocalanus**, in the southern region, though high abundance was noticed in the northern part. Of the 12 species of **Haloptilus** eleven species were encountered from the eastern Indian Ocean. **Phyllopus** showed affinity to equatorial waters. **Arietellus** was more common in the southern Indian Ocean.

c) **Bivalve Larvae:**

In the coastal waters of Kenya, most of the bivalve larvae belonged to the family Finnidae. Collections from 0-35 m depth indicated the presence of big swarm in that region. Examination of samples from other areas of Arabian Sea showed larvae which could be provisionally assigned to families Mytilidae, Veneridae, Pinnidne, Teridinidae and Osteridae.

d) **Fish larvae:**

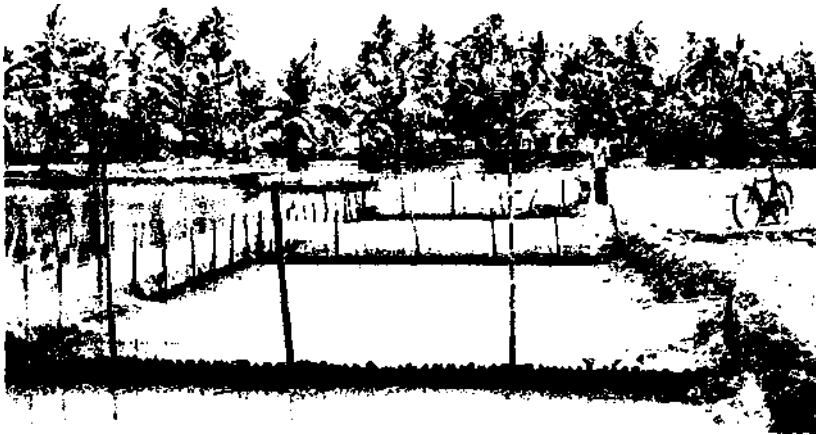
The larvae of fishes belonging to the family Carangidae, a significant component of the marine fisheries, were recorded from 8.8% of the stations in the Arabian Sea and 13.2% in the Bay of Bengal. However, their total contribution in these two areas together came to only 1.1% of the total larvae collected. Arabian Sea recorded the highest number of larvae of 141 per haul from a station at 20°32'N - 59°55'E. From Bay of Bengal the highest number was 40 per haul from Stations at 11°49'N - 92°53'E. This group was mainly represented by the genera **Decantrerus**, **Megalaspis**, and **Caranx**. From the Arabian Sea they were collected all the year round except in February and September, whereas in Bay of Bengal their absence was noticed in October-November months, indicating their prolonged breeding season over an extensive area in the coastal, offshore and oceanic waters.

2. Coastal Aquaculture.

a) **Habitat oriented distribution of prawns and their bearing on culture practices:**

A study of the distribution pattern of **Penaeus indicus** in the culture system of the Cochin backwater has revealed that their distribution during day time showed a positive correlation between size and depth; the sluice pit — the deepest area having a depth range of 150 - 270 cm were occupied by prawns measuring 11.5 to 14cm and prawns below 5 cm length were dominant in the shallow open field. After sun set, however, this demarcation disappeared.

Studies on the juvenile **P. indicus** indicated that its growth was higher in 100 to 140 cm deep ponds. The gradually increasing growth rate becoming rather sharp in the 100 cm deep pond. The average final length of prawn in the ponds varied from 6.1 to 9.75cm in 40 to 140 cm deep ponds respectively.



A series of culture enclaves inside the paddy-cum-shrimp culture system to study the effect of depth on the growth of juveniles of **P. indicus**.

b) Ecological investigations of the culture fields in relation to optimum conditions for prawn production:

Laboratory investigations on the ecological niches relevant to prawn production and related physiological aspects have also been initiated. Data have provided some information on the suitability of various conditions for growth of prawn.

c) Aquaculture investigations as rural development programme:

An inexpensive technology for large scale cultivation of feed organisms, **Apseudes chilensis** has been evolved at this Centre. This species was found to be ideal for this purpose being a hardy species highly preferred by prawn and easily preyed by them and because of its fast population growth. Economic aspects of its large scale culture are being worked put

3. **Chemical Oceanographic studies in the coastal and offshore waters of the Arabian Sea and Bay of Bengal and the adjacent seas of the Indian Ocean.**

a) **Studies on the salinity intrusion into the upper reaches of the Cochin backwater:**

The study was extended to the south of the Cochin harbour entrance up to 30 km into the Muvattupusha river. Unlike the Periyar river system there is a paucity of industries in this region alongside the river and hence distortion in the chemical data from external sources is much less conspicuous in the water samples from this segment of the backwater. Fluoride/chlorinity and phosphate values were much lower in this region. The silicate values showed a progressive decrease from the river to the estuary and a linear relationship with chlorinity unlike in the northern portion where no clearcut relation could be established.

b) **Chemical Oceanographic Studies in the Arabian Sea and Bay of Bengal:**

During the 140th cruise of RV **Gaveshani**, 38 stations along perpendicular sections covering the shelf and slope regions between 15°N and 8°N lat. in the Arabian Sea and 10°30'N to 12°N lat. in the Bay of Bengal were covered in the month of June when the Southwest monsoon is active. In the Arabian Sea the dissolved oxygen saturated layer is restricted to the upper 30 — 40m on the shelf, below this level was a sharp fall in the oxygen concentration. In the offshore region this layer extends down to 50 to 75m. In the Bay of Bengal this well mixed layer extends down to 75 to 100 m. Inorganic phosphate concentration in the waters was found to be high except at the upper 50m. The lesser concentration in the surface layers may perhaps be due to its utilization by primary producers.

4. **Protection of the marine environment and monitoring of pollutants along the Indian coast.**

a) **Bacteriological studies:**

Observations on heterotrophic bacterial population from the beach sand and surf water were made anew from eleven stations distributed along the coast from Mangalore to **Kanyakumari**. Samples were taken from surface and from the "water table level" (WTL) in the three tidal levels on each beach. The main bacterial genera were **Achromobacter** spp., **Vibrio** spp., **Flavobacterium** spp., **Photobacterium** spp. and **Pseudomonas** spp. Most of the physiological groups were recorded and **Pseudomonas** spp. were found to be nitrate reducers. Stray incidence of **Serratia** spp (pink coloured) and **Bacillus** spp. (black) were recorded from more polluted bench like Cape Comorin east

b) **In-depth studies on Aquatic Pollution:**

On the programme of sewage treatment, using phytoplankton. 15 species of phytoplankton were studied although only one resistant species viz. **Synechococcus** sp. (Cyanophyceae) showed promise in the waste water treatment of the industrial effluent.

Culture media consists of a mixture of industrial effluent and sea water of different concentrations, viz. 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100%. The maximum growth yield was obtained in this study for **Synechococcus** sp. at concentrations of 40, 50 and 60% of waste water. It is interesting to note that 70 to 80% of the nutrients were utilised from this mixture. Table I shows the growth

data of *Synechococcus* sp. in 50 and 60% of the waste water — sea water mixture. This species proved to be prolific grower as indicated by high yield of 1.8 — 1.9 g dry weight/m³/day with C/ N ratio of 8.6 - 8.7. More detailed study is in progress.

TABLE 1.

Growth data for *Synechococcus* sp. (dry wt. equals 10% of wet wt.).

Expt. No.	Experi- mental period in days	Biomass-wet weight(g/l)			Yield dry wt. [gm/m ³ /day]	C/N (wt. basis)
		Initial	Final	increase/day		
1	14	1.232	1.497	0.019	1.9	8.6
2	14	1.325	1.579	0.018	1.8	8.7

c) **Bioassay Studies:**

Laboratory studies using axenic algal cultures were conducted with varying concentrations of crude oil to determine its effect on phytoplankton.

The lethal concentrations of oil ranged from 2 ml/l to 10⁻² ml/l. Cessation or retardation of cell division occurred, depending on the species at concentrations of 0.5 ml/l to 10⁻⁵ ml/l. The rate of cell division of most of the algal species did not differ from the control at concentration between 10⁻⁴ ml/l and 10⁻⁶ ml/l. Out of the 13 species tested, the death or retardation of cell division occurred in 10 species at an oil concentration upto 10⁻³ ml/l. *Prorocentrum micans* (Dinophyceae) was the most sensitive and had a safe concentration of 10⁻⁶ ml/l., for diatoms, the safe concentration varied between 10⁻⁴ and 10⁻⁵ ml/l; for *Scenedesmus ouedricauda* (Chlorophyceae) it was between 10⁻² and 10⁻³ ml/l, and for the most resistant species *Synechococcus* sp. (Cyanophyceae) it varied between 10⁻¹ to 10⁻² ml/l.

d) **Aquatic Pollution Studies:**

Studies on indicator organisms of organic pollution in two sites in the Cochin backwater having different sources of pollution, one from retting of coconut husk and the other from discharge of municipal wastes showed that *Paraheteromastus tenuis*, a capitellid polychaete totally dominated the benthic community of the retting ground maintaining high population densities even during the premonsoon season when the adverse effects of pollution were severe. In the area of municipal waste discharge the community was dominated by a spionid worm. *Prionospio polybranchiata*.

Zooplankton studies in the estuaries of Kerala coast showed that among the 51 species of copepods encountered in these estuaries, species belonging to the families Acartiidae, Pseudodiaptomidae and Paracalanidae formed the bulk of the copepods accounting 85 to 95% of the total population. High saline copepod species exhibited high degree of correlation among themselves. Medium saline species like *Acartia plumosa* and *Acartiella keralensis* showed significant cor-

relation between each other but were negatively correlated with the high saline species. **Acartiella grevelyi** always stood separate exhibiting negative correlation with all other species.

5. Coastal Zone Management (Physical Aspects).

The main study during the year under this project was on the dynamics of silation in the Azhikode estuary. After a preliminary survey in 1983, detailed investigations were started in January, 1984. The data for examining steady state distribution of different parameters like current speed, salinity, temperature, concentration of suspended sediments etc. were collected.

Another important work carried out under this project was a study of the oceanographic conditions during June-July on the continental shelf along the southeast and southwest coasts of India in view of its important bearing on the spawning success of the major clupeoid and scombroid fisheries of India. Along the southwest coast, the isothermal layer gradually decreased southwards during the period of study from 50 to 30 metres. Along the southwest coast this layer was 50 - 75 metres deep.

Analysis of the sedimentary characteristics of the beaches of Kavaratti Island (Lakshadweep) showed the existence of a fairly regular to- and fro- transaction of the coastal sediments along the beaches — a northward movement from the southern tip of the island during the monsoon months being reversed after the season following a similar change in the littoral current patterns. However, this process did not bring a complete recovery of the beach material in the southern part of the island during the period of investigation.

4.2 Regional Centre, Bombay

A. R & D PROJECT

1. Waste assimilation capacity of coastal waters along the west coast of India and the impact of pollution on the marine ecosystem.

a) Physical investigations:

General hydrography, circulation pattern and waste dispersion capacity of the receiving water body were done along selected regions. The stations selected are located off Uran (Bombay), Tapi River estuary (Surat) and off Sutrapada (Veraval). Studies on the shore stability off Sutrapada were undertaken to evaluate the erosion and associated factors with special reference to the monsoon.

b) Chemical investigations:

Fluoride in polluted and unpolluted estuarine environments: Mindhola River estuary which receives industrial waste containing high concentration of fluoride and Purna River estuary which is free from fluoride contamination were investigated. While fluoride behaved conservatively in Purna estuary, significant deviation from the theoretical dilution line (TDL) in the chlorinity range of 0.5-8‰ was observed in Mindhola River estuary due to the externally added fluoride which largely remained in solution. The excess of fluoride over the theoretically calculated was maximum around the chlorinity of 3‰. High natural fluoride content of the river water resulted in F/Cl ratio exceeding 300×10^{-5} at low chlorinities. The ratio decreased rapidly with increasing chlorinity and the value near to that of the sea water was observed at chlorinities above 14‰.

Oil Pollution:

Nepean Sea road Oil Spill: In continuation with earlier work on source identification of the oil spill, composition of the sample was evaluated further. Its paraffin wax, asphalt and metal contents were determined. Very high wax and iron contents revealed that it is a tanker sludge. The nature and boiling point indicated it to be a tanker washing near shore. Various observations were made from its IR and conclusions were drawn particularly on the basis of sharp and intense doublet occurring at 730-720 cm^{-2} .

Composition of used crankcase oil and its interaction with water: The coastal marine environment of Bombay in particular, the creeks and bays are heavily polluted by industrial and sewage wastewaters. The effluents from refineries and other associated petroleum based industries have been adding variety of petroleum products into receiving water body. The Mahim River estuary is considered to be the most polluted area in the region and receives large quantities of domestic as well as industrial waste. An automobile service station drains substantial quantities of used crankcase oil, without any treatment, in the estuary. The oil released forms a thick layer on the receiving water and flows into the lower estuary during low tide adding to the existing sewage pollution. Our interest was to study the change, if any, in the composition of the used crankcase oil and its fate in the receiving water body by using Infrared Spectroscopy.

A widely spread band at about 3400 cm^{-4} may be due to intense darkening of the oil during use. The nature of additives was determined as unsaturates ($1700 - 1600\text{ cm}^{-1}$). The decomposition of the oil during use was clearly evident from the emergence of additional band in the region $1770 - 1770\text{ cm}^{-1}$ which correspond to carbonyl compounds. Preparative TLC was used for further detailed study. IR absorption bands of estimated fractions indicated probable transformations of saturates and further oxidation of carbonyls into acids, esters and peroxides. Nitrates were also detected. Presence of esters appeared to be due to condensation of acids with alcohols already present in the oil as additives. Distinguished bands at 1740 , 1155 and 840 cm^{-1} were found useful to monitor changes in the oil during use.

Number of laboratory simulation experiments were carried out on used crankcase oil and pure crankcase oil No. 40. Their water soluble and dispersed portions were characterised by TLC and identified using PMR and IR as long chain aliphatic hydrocarbons and their unsaturated, Keto, ester and alcohol derivatives having varied degree of branching. Percentage of these oxygenated compounds was however, very high in aqueous portion obtained from used crankcase oil, though they were present in minor quantities in the parent oil. Thus the source of contamination found to be used is crankcase oil only. The above results were compared with the samples obtained from the Mahim River estuary.

Oil spill investigations:

Number of transmittance ratios of certain peaks in IR of samples of crude oil origin were computed. A scheme of graphic presentation is being developed to characterise oil spill samples into various categories such as weathered crude oil, lube oil, tanker sludge and fuel oil. The method is presently being evaluated by considering known and unknown spills.

PMR studies, determination of specific gravity, wax content, etc., are being standardised to supplement the IR findings.

c) Biological investigations:

Phytoplankton:

A detailed study in the distribution of chlorophyll and phytoplankton was made in the nearshore waters of Mithapur. Cell counts and chlorophyll-a varies from 0.8 to 20.32×10^4 and from 0 to 19.12 mg/m^3 respectively. In general, phytoplankton population and pigment values were higher during ebb than flood periods. However, species diversity of phytoplankton indicated different pattern of incidence with higher number of species during flood than ebb periods. Maximum cell counts and pigment values were recorded in March with considerable reduction in their values during April and December. **Nitzschia** was the dominant genus in the area of study. Other common genera were **Asterionella**, **Chaetoceros**, **Coscinodiscus**, **Fragilaria**, **Navicula**, **Pleurosigma**, **Rhizosolenia**, **Synedra**, **Thalassionema**, **Thalassiosira** and **Thalassiothrix**.

Zooplankton:

Distribution of zooplankton off Mithapur was studied during the premonsoon and postmonsoon periods at ten stations inside the Gulf as well as nearshore waters off Mithapur. During the premonsoon period zooplankton biomass

was more in the Gulf area (av. 5.02-ml/100m³) than the nearshore waters (av. 2.19 ml/100 m³).

In general, zooplankton standing stock is quite low in the area with the lowest values recorded during the postmonsoon period (av. 0.56 ml 100 m³).

Zooplankton studies off Porbandar along three transects covering 9 stations showed the high productivity of these organisms. During the premonsoon period the average biomass in the area amounted to 11.55 ml/100 m. Maximum zooplankton biomass was recorded during the postmonsoon period (av 33.78 ml/100m⁻¹) In general, the flood period sustained higher biomass than the ebb periods.

Diurnal variation of zooplankton alongwith physicochemical parameters were studied at Mahim and Thana Creeks. Bombay. The Mahim Creek receives mainly domestic sewage while large quantity of industrial waste is being discharged into the Thana Creek. Adverse effects of pollution was well defined during low tide with concomitant variations in zooplankton biomass during different tidal conditions. Zooplankton biomass fluctuated from 0.97-25.02 ml/100m³ at Mahim Creek, whereas at Thana Creek the observed variation was from 1.5 - 17.28 ml/100 m⁻¹. Incidence of various species indicated characteristic species assemblages at the two stations.

Benthos:

Hydrographical data and faunastic details of benthos from seven stations of Mahim Bay were collected for evaluating the extent of pollution caused by sewage and industrial discharges. Relatively very poor macrofauna recorded at stations located close to the outfall were found to be associated with the deterioration in water quality especially during ebb period. Well defined increase in diversity of macrofauna was encountered towards the Bay mouth and outside the Bay limit with an appreciable improvement on the water quality.

B. SPONSORED PROJECTS

Details of work carried out are given under chapter on "Sponsored/Grant-in-aid Projects".

4.3 Regional Centre, Waltair

A. R & D PROJECT

1. Coastal studies off Waltair and adjacent areas.

Under the above project, the studies are broadly categorised as follows:

- a) Marine Geological and Geophysical surveys for the exploration of near-shore minerals and to study the crustal structure over the continental margins including deciphering the boundary between the continental margins and the deep oceans.
- b) Physicochemical properties of water masses in the nearshore regions to study their seasonal variability and to orient the studies towards the marine productivity and marine pollution control.
- a) **Marine Geology and Geophysics:**

The marine geological and geophysical studies mainly comprise of recording continuous bathymetry, total intensity of the magnetic field and also continuous seismic profiling in the nearshore regions covering upto 30m water depth to decipher the areas that are potentially rich in the placer deposits. Under this programme these surveys have been carried out, off Gopalpur along the Orissa coast and off Lawson's Bay along Visakhapatnam coast. In both these areas the sediment samples were also collected. The magnetic data and the sediment samples collected off Gopalpur is of very low percentage, the magnetic anomalies recorded in this region are of very low amplitude and could not signify much importance for delineating the areas with higher percentage of placer deposits by geophysical surveys. Off Lawson's Bay, the magnetic data was collected using the Magnetometer supplied by NGRI, Hyderabad. Several significant anomalies of the order of about 800 to 900 gammas have been recorded. The preliminary analysis of the data has indicated some structural features in addition to the concentration of the placer deposits. The magnetic surveys in the Lawson's Bay region are being repeated for confirmation and also to formulate the geometric models, that are responsible for causing the high amplitude anomalies. These studies are also now extended to cover the continental shelf between Visakhapatnam and Kakinada. Several profiles both parallel and perpendicular to the coast are being covered to record the magnetic, bathymetric and seismic profiler data. These studies were started in December, 1984.

Under the programme to delineate the structural features over the continental margins of east coast of India, geophysical surveys have been undertaken in Oct., 1984 on board RV **Gaveshani** covering the area between 19° N and 15°30' N and between the east coast of India and 88° E. During these surveys, the total intensity of the earth's magnetic field was continuously recorded covering more than 4300 line kms. The magnetic data has been processed with the help of the HCL Microprocessor installed at Regional Centre, Waltair and the magnetic anomalies were computed for all the profiles. The qualitative analysis of the anomalies indicate the significant anomalies over the continental shelf, over the shelf edge and also in the region between 85° and 86° E. The quantitative interpretation of the anomalies including the formulation of models to

delineate the major structural features within the ocean bottom that are responsible for creating these anomalies, is in progress.

In the regions upto 15m water depth the sediments mainly consists of medium and fine sands and the percentage composition of the heavy minerals in bulk vary from 10 to 20%. Between 15 and 30 m water depth the sediments comprise mostly coarse sands and the heavy mineral concentration in bulk does not exceed 5 per cent.

b) (i) Physical Oceanography:

The hydrographic data collected within the harbour and off Visakhapatnam have been analysed. It is observed that the upwelling is predominant off Visakhapatnam during premonsoon and monsoon periods. During October and November, the isotherms and isopycnals indicate the vertical circulation downwards which is characteristic of sinking along Visakhapatnam coast. The observed mean upwelling speed is of the order of 9.6×10^{-4} cm/s during March and April and 7.7×10^{-4} cm/s during May to July. The sinking speed is of the order of 5.77×10^{-4} cm/s in October and November. Collection of temperature, salinity and current data along 3 transects, one each of Pentakota, Kakinada and Bhiravapalem have been initiated in December, 1984. Each profile extends upto 40m water depth from coast. Studies have also been initiated to measure the currents and temperature off Kakinada covering the tidal cycle for each month. The studies are also being undertaken in the inner and outer harbours off Visakhapatnam to cover the spring and neap tidal periods to know the transport of the discharged pollutants.

(ii) Chemical Oceanography:

Under the studies for marine pollution control, the data collected over the tidal cycle at monthly intervals were analysed with special emphasis on the seasonal and tidal fluctuations of hydrochemical characteristics. The values of nutrients and dissolved oxygen show tidal fluctuations and the seasonal variations of these nutrients show two major peaks in the pre-monsoon and post-monsoon season consistent with two plankton blooms. During the 121, 130 and 142 cruises of RV **Gaveshani**, the sediment samples were collected at different stations with a view to study the distribution pattern of trace metals. The analysis for Fe, Mn and organic carbon have been completed in addition to the estimation of mercury. The statistical analysis of this data to know interrelationship between metals and sedimentary variables is in progress. The water samples collected during the same cruises were analysed the estimation of nutrients and iodate. The results indicate the biological involvement of iodate like other nutrients in the surface waters. The interrelationship between iodate and other nutrients, and the percentage depletion of iodate in the surface waters have been established. Studies have been initiated in Dec. 1984, for the distribution of chemical parameters along the three transects of Pentakota, Kakinada and Bhiravapalem to understand the local influence and the seasonal variations and the chemical parameters of the coastal waters. Hydrographic studies are also being carried out in the Kakinada port to estimate the state of pollution.

Computer programmes have been developed, tested and being used for the data processing, analysis and interpretation of marine magnetic data.

MAGDATA: This programme is used to process the magnetic data. It computes the distance between successive observational points, the magnetic field anomalies at each observation point as well as the latitude and longitude of each observation point from the navigational data obtained from the SATNAV system. This programme also interpolates the data and finally gives the magnetic anomalies at equal intervals of distances.

WERNER FD: This programme computes the distance, depth to the causative sources and also calculates the susceptibility and dip of the body. It can take any number of anomalies at a time, depending upon the memory available in the computer. It can also iterate these values to get the finer details of the body parameters.

MAG2D: This programme computes the magnetic anomalies from the theoretical two-dimensional polygonal bodies. Any number of bodies can be fed at a time depending upon the memory available.

B. SPONSORED PROJECTS

Details of work carried out are given under chapter on "Sponsored/Grant-in-aid Projects".

5

Oceanographic Cruises

During the year under report, 35 cruises were undertaken for oceanographic studies, of which 25 cruises by RV **Gaveshani** and 10 by ORV **Sagar Kanya**.

Of the 25 cruises of RV **Gaveshani** three cruises were carried out in the Arabian Sea to study the pre-upwelling conditions of the Sea. This year three cruises were carried out in the Seychelles waters at the request of the government of Seychelles under a collaborative programme. One cruise was carried out in the Lakshadweep Sea and two were organised for geological and geophysical surveys off the continental margins of the south west and east coast of India. Three cruises were organised for sponsored work — one for ONGC to study the biofouling of the ONGC installations off Bombay and two for Naval Physical Oceanography Laboratory, Cochin, for conducting some special experiments on the underwater sound propagation off Kerala Coast. One cruise was carried out in the east coast of India to study the estuarine region of river Hooghly and the mouth of rivers Hooghly and Mahanadi.

Of the ten cruises of ORV **Sagar Kanya** during the year, four cruises were organised in the Central Indian Ocean region for studies related to survey of polymetallic nodules. Two cruises were devoted to study circulation, heat and salt balance, air-sea interaction and dynamics of monsoon depression in the Bay of Bengal. One cruise was conducted in the continental shelf off the Gulf of Kutch for collection of time series data on currents and tide for the proposed 600 MW Tidal Power Plant.

Several scientists from the Universities of Andhra, Calcutta, Cochin and Berhampur, India Meteorological Department, Space Application Centre, Oil and Natural Gas Commission, Centre for-Earth Science Studies and Naval Physical and Oceanographic Laboratory, Cochin, also participated in these cruises.

CRUISES OF RV GAVESHANI

Cruise 130 (Chief Scientist: S. P. Fondekar)

This cruise was organised to conduct hydrographic, hydrochemical pollution and marine biological studies in the coastal waters along the east coast of India between Visakhapatnam and Nagapatnam. Samples were collected at 21 stations. Newston net was towed at 2 stations to examine the occurrence of floating tar particles.

Inshore waters were found to be saturated with oxygen whereas at offshore stations, a gradient with depth was observed and low values of oxygen were found below 200 m. Nitrate was absent down to about 50 metres while phosphate was always present in the surface layers. At one station, salps were very rich and contributed the highest biomass in the zooplankton.

Fourteen scientists from NIO and one each from Andhra and Calcutta University participated in the cruise. The cruise started from Visakhapatnam on 1 January, 1984 and ended at Cochin on 14 January, 1984.

Cruise 131 (Chief Scientist: V.S. Rama Raju)

This cruise was particularly planned at the request of the Naval Physical and Oceanographic Laboratory, Cochin of the Defence Research and Development Organisation for conducting some special experiments on the under water sound propagation and for collecting oceanographic data off Kerala coast. The observational programme consisted of collection of oceanographic data from two stationary positions off Cochin for about 26 hrs each, sediment sampling, spark array, side scan sonar surveys and acoustic propagation studies.

In the area surveyed the sea surface temperature varied between 27.8°C and 30.2°C. An isothermal layer was noticed extending from surface to a depth of about 50 m. with temperature around 28.4°C. The sea surface salinity showed values varying between 32 and 33‰ with slight increasing values with increasing distance from shore. The preliminary analyses of sediments indicated the presence of silty fine sands at stations with depth between 36 and 45 meters. The calcium carbonate content was found to increase with depth of water and the size of the sediment. The sparker records indicated depth penetration of about 20 metres.

Five scientists from NIO and nine scientists from NPOL participated in this cruise. The cruise started on 15th January, 1984 from Cochin and ended on 19th January at Cochin.

Cruise 132 (Chief Scientist: K. J. Peter)

This cruise was multidisciplinary one involving biological, physical and chemical oceanographic survey of the South West coast of India between Cochin and Bombay for studying the pre-upwelling conditions in the area.

The cruise consisted of six legs between 10°N and 15°N with 26 stations in shallow and deep waters. Thirty seven zooplankton samples were collected using HT and Bongo nets. Van Dorn sampling was done at 24 stations for the measurement of primary productivity, ATP, surface chlorophyll, Nitrate - Nitrogen, Nitrite - Nitrogen and Phosphate - Phosphorus. Hydrocast was made from 24 shallow and 12 deep stations. Surface meteorological observations were carried out at all stations. Wave recorder was also used except at one station. time series observations for 48 hrs were made at a mooring station off Mormugao.

Seventeen scientists of the Institute participated in the cruise which started from Cochin on 21st January, 1984 and terminated at Bombay on 31st January.

Cruise 133 (Chief Scientist: R.R. Nair)

This cruise was planned under a collaborative programme between the Governments of India and Seychelles to carry out oceanographic studies in the waters around Seychelles. The Seychelles Government was interested in getting the assistance from NIO mainly in the exploration of manganese nodules, survey of seaweed resources, feasibility studies on mariculture and siltation studies in Port Victoria. Thus RV **Gaveshani** called on Port Victoria, Seychelles on 4 March 1984 with scientists on board. During the cruise, continuous echosounding and

magnetic records were obtained. Nine stations were occupied. The sampling was carried out by boomerang and photoboomerang grabs, 4 of these being operated at each station.

RV Gaveshani sailed from Goa on February 21, 1984 and the cruise ended on 4 March, 1984.

Cruise 134 (Chief Scientist: R.R. Nair)

RV Gaveshani sailed out of Victoria Harbour, Seychelles, on 6 March 1984.

The main objective of this cruise was to explore for polymetallic nodules in the Exclusive Economic Zone of Seychelles as well as to obtain supporting biological, physical and meteorological data at the request of the Republic of Seychelles. Continuous echosounding and magnetic data each totalling 4000 line km were obtained. A total of 40 stations were occupied in the EEZ for geological sampling. Of these 30 stations were in the deep sea and 10 stations in the Seychelles continental shelf area. Sixty four operations of boomerang grab and 20 operations of photoboomerang grab were carried out resulting in the recovery of manganese nodules and a variety of sediment types. An interesting finding was the discovery of a hitherto uncharted ridge rising to a height of 1500 m in a water depth of 4700 m. In addition to the above geological work, 43 biological samples, 34 water temperature profiles, 30 wave records and 7 deep water samples were collected. Continuous meteorological data were also collected during the cruise. A temperature gradient of 20°C between the surface and 700m depth was observed in the EEZ.

An additional and equally important aspect of the cruise was the work carried out in the nearshore waters by a 5-man team of biologists, geologists and a surveyor. This consisted of the estimation of the seaweed resources of the islands of Mahe, Praslin and La Digue, a preliminary bathymetric survey and sea-bed sampling at Port Victoria, Mahe in order to evaluate the extent of siltation in the harbour, and the geomorphological study of the beaches and coasts to evaluate areas of erosion and potential sources of sediment input to the harbour.

Cruise 135 (Chief Scientist: R.R. Nair)

RV Gaveshani sailed from Mahe on 30 March, 1984.

Continuous echosounding and magnetic profiles were obtained on the way to the first of the 11 stations in the Arabian Basin and also between the other stations, where possible. Geological samplings were carried out by a combination of Petterson grabs and boomerang and photoboomerang grabs. Depending on water depth, calcareous ooze or brown clay were recovered.

RV Gaveshani returned to Goa on 11 April, 1984. The cruises (133-5) were carried out by a 19 member multidisciplinary team from NIO.

Cruise 136 (Chief Scientist: V.P. Devassy)

This cruise was organised to study the sea surface temperature, trace metal analyses, dissolved organic nitrogen, regeneration of nitrogen by zooplankton, export of dissolved nutrients by coral reefs to the oceanic waters, evaluation of biomass, production and turn over rates of heterotrophic microflora of the seas around the Lakshadweep island.

A very intense **Trichodesmium** bloom at 15°20'N, 73°41'E was observed for about 600 km distance. Data was collected along the cruise track using the Sea Surface Temperature Scanner. Fauna from the beach and lagoon were also collected. Aluminium test panels were exposed at different depths in the lagoon to find out the intensity of biofouling organisms. 16 water samples were collected from the lagoon for nutrient analyses and 12 water and sediment samples were collected for analyses of Vanadium. Samples were also collected for estimating the concentrations of Cadmium, Copper and Lead and to study the relative synthesis of lipids, polysaccharides, proteins and low molecular weight compounds during photosynthetic carbon assimilation.

Fourteen scientists from NIO and four scientists from other organisations participated in this cruise, the duration of which was 12 days from 22 April to 3 May, 1984.

Cruise 137 (Chief Scientist: A.B. Wagh)

This cruise was undertaken for a sponsored project work of Oil and Natural Gas Commission for "Biofouling studies". Environmental baseline studies around ONGC installations in Bombay High area — off shore as well as coastal — were carried out. In addition sedimentological composition and extent of petroleum hydrocarbons in the sediments were studied.

The data indicated that the off shore structures have a definite impact on the benthic biomass, their values being quite high at stations nearer to the platform. The analysis of petroleum hydrocarbons did not give any indications of oil pollution.

The ship sailed from Mormugao Harbour on 3 May, 1984 and returned on 7 May 1984. Ten scientists from NIO and three from ONGC participated in the cruise.

Cruise 138 (Chief Scientist: M.K. Anthony)

The two main objectives of this cruise were:

- i) To understand the behaviour of the coastal currents using moored current meter arrays, and
- ii) To monitor upwelling by in situ observations and remote sensing techniques.

The mooring was deployed at a pre-selected site. A hydrographic section along 15°N was taken before and after the deployment of the mooring. Hourly MBT observations were made along with the collection of data on wind and surface meteorological parameters. A sharp temperature gradient between 50 and 75 meters was noticed, the maximum gradient observed being 3.6°C. Quanta spectrometer and radio sonde were also operated.

The ship sailed from Mormugao Harbour on 7 May, 1984 and returned on 21 May, 1984. Seven scientists from NIO and three from India Meteorological Department participated in the cruise.

Cruise 139 (Chief Scientist: LV.G. Rao)

The primary objective of the cruise was to study the oceanographic properties off southwest coast of India with special reference to coastal upwelling, before the onset of southwest monsoon. During the cruise, data on physical,

chemical and biological parameters were collected, and 39 stations were occupied. Data on variation of temperature and humidity with height in the atmosphere have also been collected twice a day (at 0000 and 1200 GMT) using radiosonde balloons to study the atmospheric conditions during the onset of the southwest monsoon. Besides, observations on surface meteorological parameters have been collected throughout the cruise, for studying the exchange of fluxes across the air-sea boundary layer.

Thirteen NIO scientists, 3 scientists from IMD and 2 scientists from Department of Marine Sciences, Karnataka University, participated in the cruise. The cruise started from Mormugao Harbour on 26 May 1984 and ended on 10 June 1984.

Cruise 140 (Chief Scientist: V.N. Sankaranarayanan)

This cruise was a multidisciplinary one with special emphasis on zooplankton studies. The area of study included shelf and slope waters of the central, south west and the east coast of India.

During the cruise 26 stations were occupied in the Arabian Sea and 12 stations in the Bay of Bengal. Surface meteorological observations such as wind speed and direction, atmospheric pressure, dry and wet bulb temperature and sea surface temperature were collected at all stations. Data on vertical thermal structures and salinity were collected upto a depth of 500 meters. Wave data was collected at all stations. 251 water samples were collected for studies on salinity, dissolved oxygen, inorganic phosphate, total phosphorus and fluoride. Zooplankton samples were collected from all the stations. North of 11° Lat. up to 14° Lat. an isothermal layer of thickness 40 - 50m was observed, where as south of 11° Lat. the thickness of this layer was reduced.

Nine scientists from NIO and three from other organisations participated in the cruise. The cruise started from Mormugao Harbour on 16 June 1984 and terminated at Calcutta Port on 7 July 1984.

Cruise 141 (Chief Scientist: S.Y.S. Singhal)

This cruise was undertaken to carry out investigations in the estuarine region of river Hooghly and the mouth of rivers Hooghly and Mahanadi. This was a multi-disciplinary and inter-agency cruise. During this cruise six anchor stations each of the duration of two tidal cycles were occupied, out of which 3 stations were in the river Hooghly and one each at Sandheads, off New Moore Island and off the mouth of river Mahanadi. At the anchor stations meteorological data and current measurements were recorded every 3 hours alongwith hydrographic casts and plankton hauls. Sediment samples were collected by Van Veen Peterson Grab and Box Corer for the analysis of benthic fauna, humic acids, petroleum and chlorinated hydrocarbons.

RV **Gaveshani** sailed from Calcutta on 27 September 1984 with a complement of 13 scientists from NIO and four from other organisations. After completing the observations, the vessel arrived at Visakhapatnam on 6 October 1984.

Cruise 142 (Chief Scientist: T.C.S. Rao)

This cruise was planned to carry out the marine geophysical surveys over the continental margins of east coast of India between 19° N and 15° N. Few stations were also planned for the physico-chemical observations of the water masses off the major estuaries.

The geophysical data were collected along eight profiles each separated by 30 nautical miles. Three stations were covered over the continental shelf off Chilka lake for physical, chemical and geological data. Continuous magnetic data was recorded throughout the cruise. A distance of 4300 line kms was covered in this cruise. The magnetic data revealed some interesting magnetic anomalies in this area. High amplitude anomalies of the order of about 800 nT were recorded over the continental shelf. The anomalies over the deeper parts of the Bay of Bengal covering upto 3000 metres are of the order of 200 to 300 nT.

The participants in this cruise included 14 scientists from NIO and 5 from other organisations. The cruise started from Visakhapatnam on 9 October, 1984 and returned to the same port on 23 October, 1984.

Cruise 143 (Chief Scientist: K. Sawkar)

This cruise was organised for oceanographic studies in near-coastal waters along the east coast of India between Visakhapatnam and Nagapatnam. Samples were collected at 16 stations and studies were conducted in physical, chemical and biological oceanography including petroleum hydrocarbons, trace metals, zooplankton and benthos. Newston net was towed at three stations to collect samples of floating tar particles.

The cruise started from Visakhapatnam on 30 October, 1984, and ended at Mormugao Harbour on 7 November, 1984. Eight scientists from NIO and one from Annamalai University participated in this cruise.

Cruise 143-A (Chief Scientist: V.P. Devassy)

The objectives of this cruise were (1) to assess the levels of pollutants especially petroleum hydrocarbons, (2) to estimate the dissolved oxygen and (3) to study the nitrate reduction in relation to hydrographical and biological factors in the central and northern Arabian Sea. In addition to these, studies on the contribution of picoplankton and several higher size fractions of phytoplankton to the total primary productivity were also carried out, during the cruise. A total of ten stations were worked in the area.

Ten scientists from NIO participated in this cruise which started from Mormugao on 10 November, 1984 and ended on 18 November, 1984.

Cruise 144-A (Chief Scientist: G.C. Bhattacharya)

This cruise was organised for training and testing of geophysical equipments off Goa. The ship sailed from Mormugao on 20 November, 1984 and returned on 24 November, 1984. Ten scientists from NIO, 2 from National Geophysical Research Institute, Hyderabad, 2 from ONGC and 2 NORAD experts participated in the cruise.

Cruise 144-B (Chief Scientist: G.C. Bhattacharya)

This cruise was planned for geological and geophysical survey of the continental margin off the southwest coast of India. During the cruise, bathymetric, seismic and magnetic data were collected along with bottom sampling. The ship sailed from Mormugao on 24 November, 1984 and returned on 4 December, 1984. Fifteen scientists from NIO, one each from the Centre for Earth Science Studies, Trivandrum, Mangalore University and Osmania University participated in the cruise.

Cruise 145 (Chief Scientist: L.V.G. Rao)

The cruise was organised to carry out hydrographic survey and current measurements off the southwest coast of India between Mormugao and Cape Comorin. During the cruise, physical, chemical and biological data were collected at 48 stations. At 8 stations, current measurements were also carried out. Time series measurements were carried out at one station for a duration of 24 hours. Apart from these, a mooring of current meters was laid at the station. The cruise started on 7 December, 1984 from Mormugao and ended on 23 December, 1984. Eleven scientists from NIO and 2 scientists from NPOL, Cochin participated in the cruise.

Cruise 146 (Chief Scientist: P.V. Sathe)

The objective of this cruise was to deploy current meter mooring and to collect optical and hydrographic data off Mormugao. During the cruise, optical and hydrographic data were collected along two transects and time series measurements of current and transmittance of light were taken at the mouth of River Mandovi. In addition, data on waves and surface meteorological parameters were also collected. The cruise started from Mormugao on 27 December, 1984 and ended on 1 January, 1985. Six scientists from NIO participated in the cruise.

Cruise 146A (Chief Scientist: P.V. Sathe)

This cruise was organised to locate and retrieve the current meter mooring which was deployed in the previous cruise. During the cruise the current meter mooring which was presumed to be lost, was retrieved with the help of acoustic tuned hydrophone receiver. The cruise started from Mormugao on 4 January, 1985 and ended on 6 January, 1985. Six scientists from NIO participated in the cruise.

Cruise 147 (Chief Scientist: D. Chandramohan)

This cruise was organised to collect data on the biological and chemical parameters along the west coast of India and Laccadive Sea. During the cruise, data were collected from 20 stations. In addition, samples of flora and fauna were collected from the lagoon of Kavaratti, Agatti and Bangaram for screening biologically active components. Also studies on total bacterial population, bioluminescent bacterial population and heterotrophic activity of lagoon waters using labelled Glucose-D were carried out. The ship sailed from Mormugao on 7 January, 1985 and returned on 23 January, 1985. Fifteen scientists from NIO and one from University of Kerala participated in the cruise.

Cruise 147A (Chief Scientist: A.F. Anto)

This was a trial cruise organised to test CTD winch. The winch was tested at 14°53'N and 72°09'E at a depth of 1800m. The ship sailed from Mormugao on 28 January and returned on 30 January, 1985. Five scientists from NIO participated in the cruise.

Cruise 148 (Chief Scientist: D. Chandramohan)

During this cruise water and sediment samples were collected from 20 stations to study the nutrients, hydrocarbons, lipids and benthos. Four students from Jabalpur University were trained in Microbiological techniques and one staff member each from Universities of Kerala, Cochin, Mangalore and Aligarh were

given onboard training in collection and analysis of samples. Ten scientists from NIO also participated in the cruise. The ship sailed from Mormugao on 30 January and returned on 5 February, 1985.

Cruise 149 (Chief Scientist: A. F. Anto)

This cruise was organised to carry out acoustic studies off Southwest coast of India sponsored by Naval Physical Oceanographic Laboratory, Cochin. Four scientists from NIO and 11 scientists from NPOL participated in the cruise which started from Mormugao on 6 February and returned on 16 February. 1985.

Cruise 150 (Chief Scientist: M. Veerayya)

The objective of this cruise was to carry out sea bed surveys along the western continental margin off Saurashtra coast. During the cruise, bathymetric data along 1725 lkm, seismic profiling using ore-sub bottom profiler along 1725 lkm, sparker profiling along 1475 lkm were carried out. Sediments samples were collected from 35 stations. Fourteen scientists from NIO and 1 from Mangalore University participated in the cruise which started on 22 February and ended on 10 March, 1985.

Cruise 151 (Chief Scientist: Mrs. Lalithambika Devi).

The objectives of the cruise were characterisation and speciation of zooplankton and pollution studies along the Gujarat coast in the Western Arabian Sea. Samples of zooplankton, water, sediments and fishes were collected for analysis. Eleven scientists from NIO participated in the cruise which started from Mormugao on 15 March and ended on 28 March, 1985.

CRUISES OF ORV SAGARKANYA

Cruise 6 (Chief Scientist: F. Almeida)

This cruise was planned for the survey for polymetallic nodules in the central Indian Ocean. During the cruise, samples were collected at 7 stations using Boomerang grabs and bottom photographs were taken using photoboomerang grabs. At four stations, underwater photographs were taken using Benthos camera. Apart from these, magnetic survey was also carried out along the cruise tracks.

The ship sailed from Mormugao on 9 January and returned to Bombay on 2 February, 1984 covering a distance of 7800 line km. Nineteen scientists from NIO, one from the Centre for Earth Science Studies, Cochin and 2 from the University of Cochin participated in the cruise.

Cruise 7 (Chief Scientist: F.S. Rao)

The objectives of this cruise were to collect geological and geophysical data in connection with the studies on polymetallic nodules and surface and upper air meteorological data from the Intertropical Convergence Zone in the central Indian Ocean. During the cruise, 29 stations were covered and gravity, magnetic and bathymetric data were collected along the tracks covering the Carlsberg Ridge, Central Indian Ocean Ridge and Geoidal Low. Apart from these, sea floor mapping was carried out, using side scan sonar, off the west coast of India.

The cruise started on 18 February from Bombay and ended on 25 March, 1984. at Bombay covering a distance of 13055 line km. Fourteen NIO scientists.

4 from National Geophysical Research Institute, Hyderabad, 5 from India Meteorological Department, 2 from Naval Physical and Oceanographic Laboratory, Cochin and one each from the University of Cochin, Centre for Earth Sciences Studies, Cochin and Govt. Polytechnic, Panaji, Goa participated in the cruise.

Cruise 8 (Chief Scientist: S.M. Karisiddaiah)

The objectives of this cruise were to survey polymetallic nodules with special reference to seabed photography in the central Indian Ocean and to carry out meteorological observations over the Somali basin to study the onset of monsoon. During the cruise 35 stations were covered. Gravity and bathymetric data covering about 12000 line km and magnetic data covering about 5000 line km were collected along the tracks. Side Scan Sonar survey was also carried out off Mormugao Harbour. The cruise started on 23 May, 1984 from Mormugao and ended at Mormugao, on 6 July, 1984. Sixteen scientists from NIO, 6 from the National Geophysical Research Institute, Hyderabad and 6 from the India Meteorological Department participated in the cruise.

Cruise 9 (Chief Scientist: D.P. Rao)

ORV Sagar Kanya sailed from Mormugao Port on 15 July, 1984 and called at Visakhapatnam Port on 27 August, 1984. The cruise was planned mainly to study the circulation, heat and salt balance, air-sea interaction and dynamics of monsoon depressions of the northern and western Bay of Bengal, during the south-west monsoon period. During the cruise, 144 stations were occupied where hydrographic and meteorological observations were carried out. Also 3 depressions were tracked in the northern bay with additional upper air observations. The cruise covered a distance of 13900 line km. Ten scientists from NIO and 5 from the India Meteorological Department (IMD), participated in the cruise.

Cruise 10 (Chief Scientist: D.P. Rao)

The cruise started on 1 September, 1984 from Visakhapatnam and ended at Mormugao on 10 October, 1984. The objective of this cruise was to study the circulation, heat balance, air-sea interaction, monsoon depressions and other aspects connected with the withdrawal of the monsoon in the central and southern Bay of Bengal. During the cruise, hydrographic, and surface and upper air meteorological observations were carried out at 75 stations covering a distance of 115000 line km. Ten scientists from NIO, 5 from IMD and 2 from the Naval Physical Oceanographic Laboratory, Cochin, participated in the cruise.

Cruise 11 (Chief Scientist: P.S. Rao)

The objective of this cruise was to collect geological and geophysical data in the Central Indian Ocean in connection with the survey of Polymetallic Nodules. During the cruise, 72 stations were covered for seabed sampling and bathymetric data along 12,790 line km, magnetic data along 9,528 line km and gravity data along 7,217 line km were collected.

Eighteen scientists from NIO, three from NGRI, Hyderabad and one each from Jadavpur and Kerala University participated in the cruise which started on 27 October, 1984 from Mormugao and ended on 10.12.1984.

Cruise 12 (Chief Scientist: R.R. Nair)

This cruise was planned to decipher the continent-ocean boundary of the southwest coast of India and to collect samples for Paleoclimatic studies. During the cruise, bathymetric, gravity and magnetic data along 4980 lkm and seismic data along 3268 lkm were collected. Sea bed samples were also collected at a few stations. The cruise started on 21 December, 1984 and ended on 3 February, 1985. Thirty scientists from NIO, five from NGRI, Hyderabad, two from ONGC, one from Centre for Earth Science Studies, Cochin and one from Andhra University participated in the cruise.

Cruise 13A (Chief Scientist: B.U. Nayak)

The cruise was organised to obtain time series data on currents and tide at the edge of the continental shelf off the Gulf of Kutch in connection with the investigations on the proposed 600 MW Tidal Power Plant in the Gulf of Kutch. During the cruise seven instrument moorings were deployed. The cruise started on 9 February and ended on 14 February, 1985 at Okha. Sixteen scientists from NIO, seven from CWPRS, Pune and 20 from CEA, New Delhi participated in this cruise.

Cruise 13B (Chief Scientist: S.P. Anand)

The objectives of the cruise were to study the oceanic circulation in relation to wind system and to study the pelagic fisheries in related aspects in the North Arabian Sea. During the cruise hydrographic data were collected from 48 stations and zooplankton samples were collected from seven stations for studies. Swarming and abundance of salps were noticed in the area off the west coast of India between 17 and 21°N. This cruise was started on 14 February from Okha and ended on 14 March, 1985 at Mormugao. Twenty three scientists from NIO and two from Centre for Advanced Studies in Marine Biology, Porto Novo participated in the cruise.

Cruise 13C (Chief Scientist: B.U. Nayak)

In this cruise the instrument moorings deployed in 13A cruise were retrieved successfully. Acoustic releases used for the moorings functioned very satisfactorily. Eight scientists from NIO, seven from CWPRS, Pune and one from Central Electricity Authority, New Delhi participated in this cruise which started on 14 March and ended on 21 March, 1985.

6

Sponsored/Grant-in-aid Projects

During the year twenty one projects were undertaken and seven projects were continued/completed of the previous years. A brief summary of the work done under each project is given below.

A. SPONSORED/GRANT-IN-AID PROJECTS

Seabed surveys for feasibility studies for Tidal Power Project, Gulf of Kutch (estimated cost Rs. 9.7 Lakhs)

This project was sponsored by Central Electricity Authority, New Delhi. About 200 lkm of shallow seismic profiling was carried out using ORE profiler and EG & G Uniboom system. Atlas Deso 10 echosounder was used for bathymetry. EG & G Side Scan Sonar system was also deployed whenever possible. Motorola Mini-ranger system was used for positioning. Apart from this, 80 sediment samples were collected. The surveys would help in understanding regional geological environment and also in planning and designing of structures.

Surveys along the alignment of the proposed outfall routes at Worli and Bandra: (estimated cost Rs. 4.93 Lakhs)

Atlas Deso 10 echosounder, ORE Profiler, EG & G Sparker and Side Scan Sonar systems were used to establish the existing level of overburden and rock on the seabed along the alignment. The project was sponsored by Municipal Corporation of Greater Bombay.

Shallow seismic surveys in Bombay High and adjacent areas: (estimated cost Rs. 2.038 Lakhs).

The main purpose of the survey was to ascertain sub-surface geology and extent of soft sediment for the jacking up of drilling rigs. Total 8 locations were surveyed for which positions were provided by Syledis System. EG & G Sparker system and ORE Profiler were used for seismic profiling. This project was sponsored by Oil & Natural Gas Commission of India.

Seabed surveys and current measurements off Mormugao and Vengurla islands: (estimated cost Rs.0.99 Lakhs)

The project was sponsored by Naval Science and Technological Laboratory, Visakhapatnam for defence purpose. Atlas Deso 10 echosounder, ORE Profiler and EG & G Side Scan Sonar system were used during the survey, which was followed by collection of 35 grab samples.

Surveys for lime-shell deposit in Vembanad Lake, Kerala: (estimated cost Rs. 3.045 Lakhs).

This project was sponsored by Travancore Cement Ltd., Kottayam, Kerala. The objective of the project is to identify a favourable horizon for exploitation

of lime-shell deposits. About 100 lkm of sub-bottom profiling, 140 lkm of echosounding and side scan sonar profiling were carried out. Further, 114 grab samples and 4 cores were collected. The report is under preparation.

Bathymetric & Side Scan Survey of Veraval Harbour: (estimated cost Rs. 1.35 Lakhs)

This project was sponsored by the Superintending Engineer, Veraval Harbour, Veraval to survey the port areas for its development and construction and maintenance of breakwater. Around 200 lkm of echosounding and 5 lkm of side scan sonar profiling were carried out by using the following equipment: 1) Atlas Deso-10 Echosounder, 2) Side Scan Sonar and 3) Sextants and station pointer.

Surveys at Hajee Bander, Hay Bander, Mole station and Pilot Jetty, Bombay: (estimated cost Rs. 1.2 Lakhs)

This project was sponsored by Customs, Bombay to locate the contraband goods suspected to be dumped in these areas. About 100 lkm were surveyed by side scan sonar, sub-bottom profiling and echosounding. The following equipment were used for the survey. Miniranger, Atlas Deso-10 Echosounder, Side scan sonar and ORE sub-bottom profiler. The report is under preparation.

Survey of marine algal resources along the central west coast for research and development and cultivation: (estimated cost Rs. 0.4 Lakhs)

Under this project sponsored by the Department of Ocean Development, New Delhi, the main objectives were

- a) To assess the marine algal resources of the central west coast.
- b) Qualitative and quantitative assessment particularly of alginophytes and agarophytes from utilization point of view.
- c) Studies on the ecology and taxonomy of marine algal species.
- d) Selection of sites for starting cultivation and
- e) Cultivation of some economically important marine algae.

Biomass studies are being carried out regularly in all the stations selected for this project. The total biomass estimation for each station surveyed was obtained.

Besides this, ecological and taxonomical studies are also in progress.

Marine survey for sub-marine outfall at Mangalore: (KIOCL Phase II, continuation of the earlier project approved in 1979-80: estimated cost Rs. 4.8 Lakhs).

This project was sponsored by Kudremukh Iron Ore Co. Ltd. Studies on the effect of the sub-marine outfall on the ecology and biota of the discharge area have been initiated in December, 1984 and will continue through May, 1985. Studies include physio-chemical characteristics of the surface and bottom water, primary productivity, secondary productivity, sediment microbiology, benthic productivity, intertidal ecology and population of boring and fouling organisms.

Studies on environmental pollution by using fouling organisms as indicators: (estimated cost Rs. 5.25 Lakhs)

Under this project sponsored by Oil & Natural Gas Commission, data on hydrocarbon concentration by various fouling organisms from the ONGC installa-

tions is being collected. Data on the suspended matter is also being collected with the help of sedimentation rate at various depths near the off-shore platforms. The study was extended to the waters off the coastal installation of ONGC at Uran and Butcher Island.

The hydrobiological survey of the Thanirbhavi area, Mangalore: (estimated cost Rs. 0.32 Lakhs)

At the request of the Mangalore Chemicals & Fertilizers Ltd., Mangalore, chemical observations were carried out in January, 1984 at five stations covering a wide area of marine environment off Mangalore into which the industrial effluents from MCF are discharged. Water samples were collected at five stations from surface and bottom covering a radius of 2 kms from the effluent discharge point. Five sets of observations were taken. Physico-chemical observations include temperature, pH, dissolved oxygen and nutrients. The results of analysis were interpreted and the report of the work has been submitted to the sponsoring agency.

Water quality determination and wastewater disposal studies in Tapi River estuary: (estimated cost Rs. 9.03 Lakhs)

The sponsors of this project, Krishak Bharati Co-operatives Limited (KRIBHCO) are setting up a giant gas based fertilizer unit at Hazira on the northern bank of River Tapi in Surat, Gujarat. Oceanographic studies of the estuarine and riverine zones of the Tapi River were undertaken to assess the feasibility of releasing the treated waste water from the plant into the estuarine region of Tapi River and to advise on the mode of release.

Oceanographic studies off Sutrapada: (estimated cost Rs. 11.5 Lakhs)

Studies on physical, chemical and biological investigations off Sutrapada (Veraval) are under progress at the request of Gujarat Heavy Chemicals Ltd (GHCL) for the proposed Soda Ash Factory. The main objectives of the study are to assess the feasibility of using the sea water for cooling and to locate sea water intake point and the effluent release site for the disposal of the seawater and other effluents. Recommendations of a suitable place for a fair weather jetty is also a part of this project.

Microbiological studies were carried out at Uran, Bombay and at Veraval, Gujarat, mainly for collecting baseline data. Using computer programme, numerical profiling of bacterial communities will be worked out which will enable to monitor the environment for any change at a later date.

Oceanographic studies off Uran: (estimated cost Rs. 4.669 Lakhs)

Oil & Natural Gas Commission / Engineers India Ltd. requested NIO to determine basewater quality and dilution characteristics of the water off Uran. This information is required by them to investigate the possibility of releasing wastewater from their LPG plant and to evaluate the likely impact on the environment.

Bathymetric and Seismic Profiler surveys in the Nagarjunasagar Lake: (estimated cost Rs. 0.13 Lakhs)

This project was sponsored by Naval Science and Technological Laboratory, Visakhapatnam. These surveys were carried out to calculate the gradient of the

reservoir bottom as well as to prepare the bathymetric contour map of the suggested location. Bathymetric data was collected on a grid pattern. The results are submitted in the form of a report.

Magnetometer search off Bhimilipatnam:

This project was sponsored by Naval Science and Technological Laboratory, Visakhapatnam. Surveys are being carried out to locate the lost instruments underwater off Bhimilipatnam. Bathymetric and magnetic data are being collected in the survey area. In addition, ground magnetometer surveys are also being carried out to monitor/stimulate the type of magnetic anomalies caused by such bodies.

Wave measurements at Uran on west coast of India: (estimated cost Rs. 10.1 Lakhs)

This project was sponsored by Oil & Natural Gas Commission and Engineers India Ltd. Continuous measurements on waves were made at Dharamtar Creek for the design of effluent disposal of the submarine pipelines. A 90 cm Datawell wave rider buoy was deployed and time series measurements on waves were made. The data is being analysed and report will be submitted to the sponsors.

Studies on the development of a portable breakwater system for controlling sediment transport at tidal entrance: (estimated cost Rs. 1.8 Lakhs)

This is a grant-in-aid project funded by Salt Commissioner, Govt. of India. The main objective of this project is to develop a portable breakwater system for regulating sediment transport in the surf zone. The laboratory model of the portable breakwater system is being developed at the wave tank facility available at the Indian Institute of Technology, Bombay. The materials for the portable frame, buoys, tethers etc. have been procured and the first designs of the portable breakwater system have been finalised.

Reconnaissance survey of Nagua beach, Diu: (estimated cost Rs. 0.062 Lakhs)

This project was sponsored by Directorate of Tourism, Govt. of Goa, Daman & Diu. Survey was carried out in June, 1984 to study the stability of the beach and the suitability of inshore waters for the development of water sports. On the basis of the survey and considering the morphological and environmental setting of the beach, a status report was prepared and submitted to the sponsors.

Marine Archaeological Studies: (estimated cost Rs. 11.00 Lakhs)

This is a Grant-in-aid project funded by Department of Science & Technology.

The Marine Archaeological studies were resumed in December, 1984 for underwater exploration of the submerged town of Dwarka of the northwest coast of Saurashtra and another town in the island of Bet Dwarka. Both the towns are traditionally known to have been built by Sri Krishna and submerged by the sea. Another objective was to collect data for eustatic studies in the Gulf of Kutch. Earlier findings suggested a 60 metre low stand of the sea level 11,000 years. Before Present which would mean that the Gulf of Kutch was almost a Rann at that time and the island of the Bet Dwarka must have been connected by land with the mainland of Okha point.

Keeping the above objects in view, expert divers were employed for excavation on the seabed and for collecting antiquities and other samples within specified areas in archaeological sites off Bet Dwarka and Dwarka. Airlifts were used for removing the overburden and an airjet for excavation. Underwater photographs and drawings of the submerged structures were also made.



A diver measures a building block of the submerged structure in the ancient harbour of Dwarka (mainland).

Two significant results of the marine archaeological investigations in 1984 are the discovery of a unique seal in Bet Dwarka waters and the identification of submerged structures in Dwarka waters. A three-headed animal motif representing the bull, unicorn and goat of the Indus Valley Civilization is drawn on the Bet Dwarka seal in Bahrainian style.



A seal of chank shell found in seabed off Bet Dwarka.

This feature and the associated pottery namely, the Lustrous Red Ware, Late Harappan Ware and the Kassite Ware suggest a date close to the 15th-14th century B.C. It has been possible to determine the extent of the submerged town in Bet Dwarka by digging the trial pits 200m seaward of the submerged toe wall and 500m seaward of the fortification wall in the cliff section. Both the walls in situ were discovered in the First Marine Archaeological Expedition in 1983. The ancient town was 1 km long and nearly 400m wide. At the northern end were two rock-cut ramps for launching boats.

Underwater excavation 100m seaward of Samudra Narayana Temple at the mouth of the ancient harbour of Dwarka (mainland) revealed submerged structural remains in which large building blocks of stone of prismatic shape were used. This discovery corroborates the onshore evidence of destruction of protohistoric township and early historic temples by the sea. Underwater photographs of the submerged structures have been taken. The nature and extent of submerged structures will be ascertained in the next season.

Besides confirming the tradition that Dwarka was submerged, the present investigations go a long way in assigning the submergence to the 14th century B.C. and thereby indicate that the net rise in sea level during the last 3,300 years is about 5 metres. This information may serve as a datum line for further study of sea level fluctuations and subsidence and uplifts.

Among important antiquities recovered from the intertidal zone and seabed are the Late Indus seal, a stone mould of a metalsmith for casting spears and chisels, shell bangles and pottery, beads and an unguent bottle.

B. CONSULTANCY PROJECT

Environmental studies for establishing Shrimp Hatchery & Pilot Fish Farm at Saphala works: (estimated cost Rs. 0.15 Lakhs)

As per the request of Managing Director, Development Corporation of Konkan Ltd. (A Govt. of Maharashtra Undertaking) an expert consultancy project was undertaken. Field observations on 8 environmental and 10 biotic parameters were undertaken during August and October, 1984. Analysis and processing of data for determining the feasibility of setting up a shrimp hatchery and pilot fish farm were carried out during November and December 1984. A report giving the specific recommendations and step-by-step details of hatchery and pilot fish farm, was finalized for submitting to the sponsors.

C. CONTINUING/COMPLETED PROJECTS OF THE PREVIOUS YEARS

- Seaweed cultivation at Malvan, sponsored by Govt. of Maharashtra, Bombay.
- Photorespiration in the marine environment, Grant-in-aid project of Department of Science and Technology, New Delhi.
- Development of microprocessor based Rotor Current Meter, sponsored by Calcutta Port Trust.
- Development of microprocessor based instruments — Tide Gauge, Digitizer, Electronic Bathythermograph — Grant-in-aid project of Electronics Commission of India
- Studies on biofouling of offshore structures, sponsored by Oil & Natural Gas Commission.
- Wave measurements off Kakinada on the east coast, sponsored by Oil & Natural Gas Commission.
- Wave-measurements at Bombay High on the west coast, sponsored by Oil and Natural Gas Commission

7.

International Programmes

International Mangrove Training Course

The National Institute of Oceanography organised the 2nd UNDP/UNESCO Introductory Training Course on Mangrove Ecosystems from November 1 to 25, 1984 under the auspices of Department of Environment, Govt. of India, New Delhi, Council of Scientific and Industrial Research, New Delhi and National Institute of Oceanography.

The main objectives were to bring together scientists, conservators and policy makers to gain an understanding of this complex ecosystem, and also create more trained manpower in this area, to study the mangrove environment properly, as well as to evaluate common strategy for proper mangrove management.

The programme was dedicated to the late Prime Minister Smt. Indira Gandhi in her memory.

There were in all 21 participants from 9 countries viz. Burma, Malaysia, Indonesia, Philippines, Sri Lanka, Australia, Thailand, Vietnam and India. The maritime States of India, i.e. Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamilnadu, Andhra Pradesh, Orissa and West Bengal had nominated the participants for training. Twenty two lecturers from India and 5 from Australia, Philippines, France, U.S.A. and U.K. delivered talks on basic, advanced and applied aspects of the mangrove ecosystems and its research.

The training course comprised of lectures, field and laboratory work as well as study tour to southwest coast of India.

The trainees presented status report on the Mangrove research in their own countries and prepared a report on the training course with their suggestions for future implementation.

The major achievements of the training course were the scientific training to generate more manpower, distribution of scientific literature, increasing awareness about the structure and function of mangrove ecosystem, exchange of new ideas as well as national and regional cooperation and coordination.

The training course came to an end on 25 November, 1984 with the valedictory function in which Dr. S.Z. Qasim, Secretary, Department of Ocean Development, Govt. of India, New Delhi was the Chief Guest. Dr. Qasim emphasized the need for intensive research and conservation measures for the benefit of this fragile ecosystem.

In this programme Dr. A.G. Untawale acted as course Director while Drs. V.V.R. Varadachari, R. Sen Gupta, T.S.S. Rao, E. Desa, S.N. D'Souza, A.H. Parulekar, S.C. Goswami, D. Chandramohan, L. Bhosle and M. Wafar delivered the lectures.

Bioactive substances from the Indian Ocean

An Indo-US collaborative project on "Bioactive substances from the Indian Ocean" was initiated during the year. The participating laboratories are National Institute of Oceanography (NIO), Goa, Central Drug Research Institute (CDRI), Lucknow and Bose Institute, Calcutta in India and Stevens Institute of Technology, New Jersey, Osborne Laboratories of Marine Sciences, New York and Department of Biological Sciences, University of Southern California, Los Angeles, in the United States of America. The three year project, estimated to cost U.S. \$88,000 will be coordinated by NIO (CSIR) from the Indian side and by Prof. A. K. Bose of Stevens Institute of Technology from the US side.

The main objective of the project is to identify marine flora and fauna from the Indian Ocean, for their biological activity and isolation, purification and structural determination of their active components. The sampling will be confined to a maximum water depth of 50m including the inter-tidal region. Extracts in organic solvents will be prepared and screened for their activities through animal tests. The respective active chemicals will then be isolated and their structures determined using most sophisticated instruments like NMR. MS etc. It is also aimed to build up a museum of all the marine flora and fauna collected during the project.

The NIO will carry out collection of samples from west coast of India for identification, fractionation of biologically active components and their chemical characterization. Further screening and testing will be done at CDRI and Bose Institute while the crystallographic and other studies for which facilities are not available in India will be done in the United States.

Four Indian scientists have already undergone training in diving, collection and identification of samples in United States.

Indo-FRG Workshop on Marine Sciences

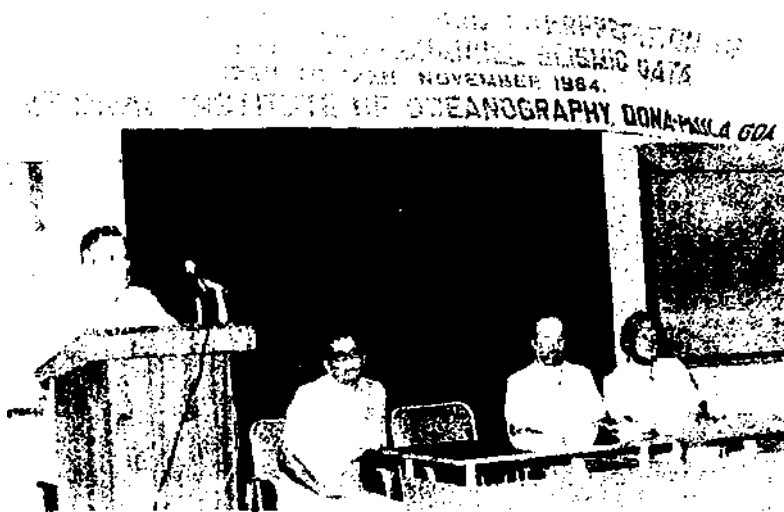
An Indo-FRG Workshop on Marine Sciences for collaboration in oceanographic research between the two countries was organised during 26-31 October, 1984. Six participants from FRG and 23 from NIO and one each from Annamalai University, CSIR, New Delhi and DOD, New Delhi attended the workshop. A draft proposal was formulated which will be submitted to the respective governments.



Prof. E.T. Degens of Hamburg University, FRG, addressing the gathering at the Indo-FRG workshop on marine sciences.

Indo-NORAD Workshop

A seminar was organised with the assistance of the Norwegian Agency for International Development (NORAD) on "Acquisition, processing and interpretation of analog and multichannel seismic data" at NIO during 12-18 November, 1984. Four scientists from Norway, twelve from NIO, Goa one from Andhra University, Waltair and two from the Oil and Natural Gas Commission of India participated.



Dr. Varadachari, Director, delivering the inaugural address at INDO-NORAD Workshop.

Indo-Australian Research Programme

i) Under Indo-Australian Research Programme several sediment samples were received for the study of microfossils. The studies revealed that among the Cytheracean Ostracods observed, two species (*Xestolaberis* sp and *Bradleya dictyon*) range from Cretaceous to Recent and *Poseidonamicus major* ranges from Pleistocene to Recent while *Paradoxostoma antarcticum* and *Loxoreticulatum fallax* are reported from Antarctica and range from Pleistocene to Recent. *Bradieva* and *Krithe* were typical deep water (psychrosphouric) forms during Paleocene to Oligocene times as today, but were found in shallow (-45 to -37m) depths in the Deep Lake region of Antarctica.

ii) Diatoms are sparsely present in sediments of Deep Lake terraces of Vestfold Hills, Antarctica. *Cyclotella stelligera*, *C. glomerata*, *Triceratium arcticum* and *Porosira glacialis* are the characteristic species. *Porosira glacialis* is very large sized (100 μm . compared to known 30-70 μm) unusual and possibly marine. This indicates reworking or mixing of marine with nonmarine material. The study indicates that the region was uplifted possibly around 4000-7000 years ago as a result of tectonic movement and also as a response to offloading of thick ice sheets which covered the area.

8.

Infrastructure

The following facilities were added during the year;-

Physical Oceanography:

- Extending the measuring range of an indigenously fabricated temperature probe from 25°-50°C to 25°-100°C and completion of its calibration.
- Installation of a rotating tank in Geophysical fluid dynamics laboratory to study the dynamics of rotating fluids.
- Calibration of a precision radiation thermometer, newly acquired from Barnes Engg. Co., USA using a temperature calibrator bath in the remote sensing laboratory.
- Successful installation of a SST thermal scanner, developed by Space Applications Centre (SAC), Ahmedabad on board RV **Gaveshani**.
- Installation of a weather station on board RV **Gaveshani** using meteorological sensors.
- Reception of Daily Weather Charts using Radio Communication receiver and Facsimile Recorders.

Geological Oceanography:

During the year, the phase-1 of the proposed Geochronology laboratory has been completed to carry out: (1) Beta radiation counter system for Ph-210, Be-10, Th-234, Ra-228 etc. (2) Alpha Spectrometry for the assay of the Alpha radiation of several U-Th series. (3) High Purity Germanium (HPGE) Gamma Ray spectrometry. (4) Radon extraction, transfer and counting system for assaying Ra-226 via Rn-222 scintillation.

The laboratory has already commenced dating of sediment cores and polymetallic nodules.

Instrumentation:

- During the Third Indian Scientific Expedition to Antarctica two satellite communication terminals were installed and successfully commissioned in the Indian Antarctic Research Station. During the expedition, the link was successfully used for the transmission of telex, telephone and slow-scan TV pictures to the mainland.
- A satellite communication system was successfully installed and commissioned on the ORV **Sagar Kenya** of the Department of Ocean Development. The system has been installed with telex, telephone and data modem facilities.
- The microprocessor development facilities were enhanced with the installation of the SP-85 and SP-86 support packages. The Microprocessor Development System MDS-236 was upgraded from a Series-II to a Series-III ver-

sion. This will now support the 16 bit microprocessor 8086, SP-85/86 package also include the In-Circuit Emulators ICE-85 and ICE-86 which will help in hardware and software debugging. Support packages also include the BASIC-80 Interpreter.

Computer:

The TDC-316 computer system was augmented in several ways, both in terms of hardware and software. Several critical time-bound jobs were satisfactorily completed. A Computer Norsk Data ND 520 super-mini computer, obtained under NORAD Programme has been installed. The different aspects of the Centre are highlighted below:

i) SYSTEM PERFORMANCE:

The system logged 1,400 hours of CPU time, and 8,000 jobs were completed,

ii) HARDWARE AUGMENTATION:

- The teletype console was replaced by a CRT terminal.
- A floppy read / write system was installed and data and programs can now be entered off-line via 8 inch floppy discs. The punch card system has been replaced by floppy medium.
- A Benson Drum Plotter with an off-line Benson Magnetic Tape Drive unit has been received under NORAD assistance. A large Benson Digitiser has been also received under the same aid programme. All three peripherals have been installed and commissioned. Work is also in progress to interface the peripherals to the TDC-316.
- A Rainbow 100B personal computer was received under an UNESCO programme, and it was successfully interfaced to the TDC-316 using the PASCII controller (see Information, Publication & Data Division report for further details).

iii) SOFTWARE AUGMENTATION:

- A new DOS-316 Operational System supporting the floppy disc entry unit was installed. The DOS version also supports Job Control Language (JCL) and has extensive mathematical and statistical system libraries.
- A "function library" of physical oceanographic functions has been implemented.
- The basic software for the use of the Benson Plotter for on-line plotting is in the process of being installed.
- General programs for users have been developed for data editing and processing of bibliographic information, current meter data, gravity data interpretation, nansen cast data and data plotting.

iv) NEW SYSTEM:

Under the NORAD (IND 013) Programme, the Institute has acquired a Norsk Data ND 520 computer with following configuration:

Hardware:

- ND 520 super mini 32 bit computer with 1 Mbyte memory.
- Two 150 Mbyte hard disc drives, with streamer tape back-up.

- Seven terminals for user entries.
- One Graphics terminal with plain paper copier.
- One Line Printer.

Software:

Plot 10 Graphics package

Major work carried out in the Computer Centre:

During the year the major data processing and data analysis work carried out on the computer system are as follows:

1. Current Meter data processing for RIHAND Sponsored Project.
2. Polymetallic Nodules data processing for Abundance and Chemical Analysis.
3. Grain-size data analysis off Lakshadweep area.
4. Aquaculture Bibliographic data processing.
5. Wave-data analysis and interpretation.

Five DCM Tandy TRS-80 Microcomputers were acquired and installed in the Institute.

Workshop:

The Workshop has been shifted to its new premises.

The new Installations in the Workshop are.

- A 5 ton overhead gantry crane has been installed and commissioned and will be an aid to transportation of heavy materials and machineries within the workshop area.
- A wood-working lathe has also been procured for the different carpentry jobs of the Institute.
- A radial drilling machine has been installed and will shortly be commissioned.

The Workshop has completed about 340 different jobs of varied nature in the last year amounting to approximately Rs. 65,000/-.

Drawing Section:

In the Drawing Section the new facilities included are:

- A microprocessor based drawing and draughting scribe has been installed and commissioned. The scribe has greatly enhanced the capabilities of the Section, and will allow high quality lettering and symboling to be rapidly carried out.

The Drawing Section has completed over 400 jobs in the last year amounting to approximately Rs. 20,000/-.

Photography Section:

The Photography Section has been catering to the needs of the different Divisions of the Institute, both in the laboratory and in the field. The support rendered by the staff of the section to scientists in the field has proved especially helpful in projects as varied as Wood Preservation and Marine Archaeology (see respective sectional reports for further details).

During the year, the section completed 340 jobs amounting to Rs. 35.000/-.

Prototype Section:

This section is responsible for layout and fabrication of the instruments developed in the Division.

- Four Direct Reading Current Meters were fabricated for R.C. Cochin and two units for R.C. Bombay during the year. These prototype jobs were carried out in collaboration with the Workshop.
- The section has also succeeded in preparing PCB negatives by colour separation technique from a single layout. This methodology ensures identical matching between top and bottom PCB layers. This work was carried out in collaboration with the Photography Section.

Library:

During the period 545 books and 265 technical reports were added to the library. This brought the total number of books and reports to 14,923 and 3,918 respectively. 220 journals on subscription and 80 journals on exchange/complimentary are being received.

A new arrangement for sharing the research journals has been made between the libraries of this Institute and Centre of Post graduate Instruction & Research, University of Bombay at Panaji. In this arrangement separate journals are subscribed by the two libraries and kept in both the libraries alternately for a specified time. This has benefitted the user and proved economical to the libraries.

The library continued the interlibrary loan service which was beneficial for the users from outside organisations. Under the current awareness services, the following titles were brought out:

New Arrivals — I	— Books (monthly)
New Arrivals — II	— Technical Reports (monthly)
Aquatitles — III	— Patents
Aquatitles	— Fortnightly

The other publications brought out by the library are a bibliography and a catalogue (details in Publications).

Construction of Scientists Apartments & Hostel:

The construction of a Guest House for the Institute has been completed. This Guest House has 9 double bed-rooms, a dining hall, a lounge and a library.

During the year, construction of 80 Scientists apartments and a Trainee Hostel with 28 rooms has been started.

Press Activities:

Printing and binding.

The printing and binding unit has extended a very great helping hand for R & D and other activities of the Institute. The Newsletter, the abstracts, various forms and registers are printed. A large amount of printing and binding work was handled.

This has not only proved economical but convenient and dependable. Reprography facilities were also liberally provided to the staff.

9

Budget

BUDGET OF THE INSTITUTE FOR THE YEAR 198445

(Rupees in lakhs)

	PLAN	NON PLAN	TOTAL
A. RECURRING			
Salaries	25.513	73.000	98.513
Contingencies	9.253	10.700	19.953
Maintenance		1.451	1.451
Chemicals & Glassware	7.738	8.300	16.038
Boat Operations	10.000	84.902	94.902
TOTAL A	52.504	178.353	230.857
B. CAPITAL			
Works	2.593	—	2.593
Services	11.615	—	11.615
Equipment	51.250	—	51.250
Furniture	1.856	—	1.856
Library Books	4.000	4.546	8.546
Vehicles		1.164	1.164
Models & Exhibitions	0.500		0.500
TOTAL B	71.814	5.710	77.524
TOTAL A + B	124.318	184.063	308.381
C. MULTI-AGENCY PROJECT	131.348	—	131.348
D. THRUST AREAS	57.152	—	57.152
GRAND TOTAL (A + B + C + D)	312.818	184.063	496.881

10

Composition of Various Committees of NIO

10.1 RESEARCH ADVISORY COUNCIL

- | | |
|--|----------|
| 1. Dr. S.Z. Qasim,
Secretary,
Department of Ocean Development,
Mahasagar Bhavan,
C.G.O. Complex, Block No. 12,
Lodi Road,
New Delhi - 110 003. | Chairman |
| 2. Dr. D. Srinivasan,
Director,
Naval Science & Technology Laboratory,
Visakhapatnam - 530 006. | Member |
| 3. Prof. M.N. Sastry,
Department of Chemistry,
Andhra University,
Waltair - 530 003. (A.P.) | |
| 4. Shri L.L. Bhandari,
Director,
Institute of Petroleum Exploration,
Oil and Natural Gas Commission,
9, Kaulgarh Road,
Dehradun- 248 001. | " |
| 5. Vice-Admiral K.K. Nayyar,
Flag Officer Commanding,
Southern Command. Indian Navy,
Cochin - 628 004. | " |
| 6. Prof. V.S. Raju. "
Department of Ocean Engineering,
Indian Institute of Technology,
Madras - 600 036. | |
| 7. Prof. Supriya Roy, "
Department of Geology,
Jadavpur University,
Calcutta - 700 032. | |
| 8. Prof. M. Gadgil. "
Centre for Theoretical Studies,
Indian Institute of Science.
Bangalore - 560 012. | |

9. Prof. R. Natarajan, "
Centre for Advanced Studies in Marine Biology,
Porto Novo,
Annamalai University,
Annamalai Nagar. (Tamil Nadu).
10. Prof. M.P. Singh, "
Centre for Atmospheric Research,
Indian Institute of Technology,
New Delhi - 110 016.
11. Dr. E.V. Chitnis. "
Director,
Space Application Centre,
Jodhpur Tekra,
Ahmedabad - 380 053.
(Gujarat).
12. Dr. E.G. Silas. "
Director,
Central Marine Fisheries Research Institute,
Cochin - 682 018.
13. Shri S.K. Das, "
Director General,
India Meteorological Department.
Lodi Marg,
New Delhi - 110 003.
14. Prof. (Mrs) T.R. Doctor, "
Head, Department of Microbiology,
M.V. College,
Andheri (West).
Bombay - 400 058.
15. Director General, Member
(ex-officio)
SIR or his nominee.
16. Director.
National Institute of Oceanography,
Dona Paula,Goa
17. Dr. A.P. Mitra, "
Director,
National Physical Laboratory &
Chairman of the Coordination Council
for Physical & Earth Sciences,
Laboratories of CSIR.

10.2 EXECUTIVE COMMITTEE

1. Director,
National Institute of Oceanography,
Goa. Chairman
2. Prof. M. Gadgil,
Indian Institute of Science.
Bangalore - 560 012. Member
3. Prof. Supriya Roy "
Prof. of Geology
Dept. of Geological Sciences
Jadavpur University
Calcutta
4. Prof. M.P. Singh, "
Centre for Atmospheric Research,
Indian Institute of Technology.
New Delhi- 110 016.
5. Shri H.N. Siddiquie
Scientist,
National Institute of Oceanography.
Goa.
6. Dr. M.D. Zingde, "
Scientist-in-Charge,
N.I.O. Regional Centre.
Sea Shell, Seven Bungalows.
Versova, Bombay.
7. Dr. A.B. Wagh. "
Scientist,
National Institute of Oceanography,
Goa.
8. Administrative Officer,
National Institute of Oceanography,
Goa. Member
(ex-officio)
9. Sr. Finance & Accounts Officer, "
National Institute of Oceanography,
Goa.

**10.3 CRUISE PLANNING AND PROGRAMME PRIORITIES COMMITTEE FOR
R.V. GAVESHANI & O.R.V. SAGAR KANYA**

1. Dr. S.Z. Qasim, Chairman
Secretary to the Government of India,
Department of Ocean Development,
Mahasagar Bhavan, Block No. 12,
C.G.O. Complex, Lodi Road,
New Delhi - 110 003.
2. The Director General, Member
Scientific and Industrial Research
Council of Scientific and Industrial Research,
Rafi Marg,
New Delhi - 110 001.
3. Shri K.N. Johri,
Head.
International Scientific Collaborations,
Council of Scientific and Industrial Research,
Rafi Marg,
New Delhi - 110 001.
4. Dr. R.K. Datta
Council of Scientific and Industrial Research,
Rafi Marg,
New Delhi - 110 001.
5. Rear Admiral D.S. Paintal,
P-7, Hauz Khas,
New Delhi - 16.
6. The Deputy Director General (Marine Geology), "
Geological Survey of India,
Ratnakar Building,
4, Chowringhee Lane,
Calcutta.
7. The Adviser,
Legal and Treaties Division,
Ministry of External Affairs,
Patiala House,
Tilak Marg.
New Delhi.

8. The Secretary,
Department of Mines,
Shastri Bhavan,
New Delhi. "
9. The Chairman,
Commission for Addl. Source of Energy,
c/o CASE, D.S.T.,
Shastri Bhavan,
New Delhi. "
10. The Chairman,
University Grants Commission,
Bahadur Shah Zafar Marg,
New Delhi.
11. The Director (Operational),
Coast Guard Head Quarters,
Ministry of Defence,
E. Block, D.H.Q. P.O.
New Delhi. "
12. The Director,
Naval Physical Oceanography Laboratory,
Naval Base,
Cochin - 682 004. "
13. The Director,
Naval Science and Technology Laboratory,
Vigyan Road,
Visakhapatnam - 530 006. "
14. The Director,
National Geophysical Research Institute,
Uppal Road,
Hyderabad - 500 007.
15. Shri J.C. Sheth.
Shipping Corporation of India,
229/232, Madame Cama Road.
Bombay - 400 021. "
16. The Director General,
India Meteorological Department,
Lodi Road,
New Delhi - 110 003. "
17. The Chief Hydrographer,
Naval Hydrographic Office,
Rajpur Road,
Dehradun- 248 001. "
18. The Chairman,
Oil and Natural Gas Commission,
Tel Bhavan.
Dehradun. "

19. The Member Offshore,
Oil and Natural Gas Commission,
Express Towers. Nariman Point.
Bombay. "
20. The Director.
Institute of Petroleum Exploration,
Oil and Natural Gas Commission,
9, Kaulagarh Road.
Dehradun - 248 001. "
21. The Director,
Centre of Earth Science Studies,
Saikrishna Building,
TC No. 9/1421, Sasthamangalam,
Trivandrum - 10. "
22. The Director,
Central Electrical Authority,
Government of India,
Bikaner House,
New Delhi - 110 011. "
23. The Wireless Adviser,
Ministry of Communication.
Sardar Patel Bhavan,
New Delhi. "
24. Adviser Ports,
Ministry of Shipping & Transport,
Transport Bhavan,
New Delhi. "
25. Shri B.S.V. Rao.
Industrial Adviser.
Director General of Technical Development,
Udyog Bhavan,
Maulanu Azad Road,
NEW DELHI - 110 001
26. Shri Vijay K. Nambian,
Director (UNP & NAM)
Ministry of External Affairs.
South Block
NEW DELHI - 110 011
27. Dr. S. Ramanathan,
Deputy Adviser (S & T).
Planning Commission,
Yojana Bhavan,
NEW DELHI - 110 001

28. Dr. Pranav Desai,
Deputy Head,
Meteorology Division,
Space Applications Centre,
Jodhpur, Terka,
AHMEDABAD
29. Shri K.R. Sachar,
General Manager (C & P S Division),
Shipping Corporation of India.
245, Madam Cama Road,
BOMBAY - 400 021
30. Dr. N.W. Nerurkar,
Joint Secretary,
Department of Electronics
Lok Nayak Bhavan,
NEW DELHI - 110 003
31. Dr. M. N. Qureshy,
Adviser (ES),
Department of Science & Technology.
NEW DELHI- 110 016
32. Dr. S.N. Dwivedi,
Director,
Central Institute of Fisheries Education,
J.P. Road, Andheri (West).
BOMBAY - 58
33. Dr. P.K. Pant,
Project Manager,
Bombay Off Shore Project,
Oil & Natural Gas Commission.
Bank of Baroda Bld..
Parliament Street,
NEW DELHI- 110 001
34. Shri V.M.K. Nair,
Deputy Secretary (Land Customs),
Central Board of Excise & Customs.
Room No. 47-A,
North Block,
NEW DELHI - 110 001
35. Commador Narender Singh,
Director,
Department of Non-Conventional Sources of Energy.
CGO Complex, Block No. 14,
Lodi Road,
NEW DELHI- 110 003

36. Shri S. Gopalan,
Director (Designs),
Ministry of Shipping & Transport.
Parivahan Bhavan,
Sansed Marg.
NEW DELHI - 1
37. Shri A.P. Tewari,
Department of Mines.
Shastri Bhavan.
NEW DELHI

11

Appointments/Resignations/Transfers

11.1 Appointments:

Scientists

Dr. N. Bahulayan
Dr. Satish Shetye
Dr. T.V. Ramana Murty
Dr. (Miss) Francisca Pinto de Souza
Dr. S. Raghu Kumar
Mr. Thayapurath Suresh
Mr. K. Sreekrishna
Mr. K. Ashok Kumar
Mr. Anil K. Chaubey
Mr. Ravi Kottur
Mr. Khadge N. Haribhau

Stores/Purchase Officer

Mr. M.R. Gurumurthy

Junior Technical Assistant

Miss C. Suguna

Junior Stenographer

Miss M. Edociana Desa
Mrs. Sheila Vaz
Miss Alison Luis

Lower Division Clerk

Miss Alka Salgaonkar

Stores/Purchase Assistant (Gr. VII)

Mr. Harish P. Maijekar
Miss V. Lata Chari
Miss Melita H.F. e Peshwe

Key Punch Operator

Mr. P.N.S. Jakhi
Mr. Mathew Dias
Mr Suryakant Naik

Staff Car Driver

Mr. John Louis

Helper (Gr. A)

Mr. Dinu P. Gaunco

11.2 Resignations

Mr. G.R. Itigi	Scientist	'B'	w.e.f.	13.10.84
Mr. K. Kodanda Ramaswamy	Scientist	'B'	w.e.f.	10.10.84
Mr. S. Sekhar	Scientist	'B'	w.e.f.	13.2.84
Mr. K.J. Daniel	Scientist	'B'	w.e.f.	21.4.84
Mr. J. Kamlakar	J.T.A.		w.e.f.	24.2.84
Miss Vilma Vaz	J.T.A.		w.e.f.	2.5.84
Mr. S.M. Pakale	J.T.A.		w.e.f.	28.2.85
Mr. Umesh Kamat	Stores & Purchase			
	Asst.		w.e.f.	29.3.84
Mr. T. Srinivas Rao	J.T.A.		w.e.f.	9.1.84
Mrs. Kanchanbala Narvenkar	L.D.C.		w.e.f.	31.8.84

11.3 Transfers

Shri V.S. Rama Raju from R.C Cochin, NIO to RC Waltair, NIO.
Dr. G. Victor Rajamanickam from NIO, Goa to R.C Waltair, NIO.
Smt. Santosh Babu from RRL, Trivandrum to R.C Cochin, NIO.
Smt. V. Latachari from NIO, Goa to CLRI, Madras.
Smt. Radhamani from NIO, Goa to CSIR Complex, Madras.

Visitors

Visitors at Headquarters

The **Vice-President of India, Shri M. Hidayatullah** visited NIO on 14 February 1984. He was accompanied by his wife Smt. Pushpa Hidayatullah and Shri K.T. Satarawala, Lt. Governor of Goa, Daman & Diu. He was received by Dr. V.V.R. Varadachari, Director, and other senior scientists. The achievements and the research and development programmes of the Institute were explained to him through display of charts and materials. The Vice-President has shown keen interest in the activities of NIO. He was greatly impressed by the work carried out at NIO and remarked that it would not only benefit the country but also the mankind in general.



Shri Hidayatulla, Vice President of India (second from right) accompanied by his wife and Lt. Governor of Govt. of Goa, Daman & Diu being explained one of the research activities of NIO.

Shri Harish Zantye, Minister for Education, Govt. of Goa, Daman & Diu, visited NIO on 23 June, 1984. He was received by Dr. V.V.R. Varadachari, Director, who took him round the Institute. Shri Zantye was greatly impressed with the various activities of the Institute especially the studies on the estuaries and coastal waters of Goa and expressed the hope that the technical knowhow available at NIO in the field of aquaculture in respect of fishes, mussels, seaweeds etc., will be put into practice in Goa. He said that the major areas of research in the exploration of minerals, energy, food and drugs from the sea, development of remote sensing techniques and ocean modelling, have been planned in the right direction and as a premier institution in the country. NIO's endeavour to contribute greatly to the knowledge of the seas around us, will certainly pay rich dividends. He also suggested that NIO should play a key role in the establishment of the proposed Goa University



Shri Harish Zantye, Minister for Education, Govt. of Goa, Daman & Diu looking at the instruments developed by NIO. On the extreme right is Dr. Varadachari Director, NIO.

A **Parliamentary Committee on Official Languages** visited NIO on 10 October, 1984. The Committee members were received by Dr. V.V.R. Varadachari, Director. Later at a meeting with the Heads of various Divisions, the Committee reviewed the progress on the implementation of Hindi as the official language in the Institute.



Dr. Varadachari, Director NIO (extreme right) showing the model of ORV **Sagar Kanya** to the members of the Parliamentary Committee on official languages.

Prof. K.M. Chandy, Governor of Madhya Pradesh visited NIO on 28 December, 1984 accompanied by his wife. He was received by Dr. V.V.R. Varadachari, Director, who took him round the Institute. He showed keen interest in the various activities of the Institute and said that he felt proud of the scientists in the Institute who were carrying out valuable and exciting work enlarging the horizon of our knowledge.



Prof. K.M. Chandy, Governor of Madhya Pradesh (third from left) discussing the NIO activities with one of the lady scientists.

His Excellency Dr. Gopal Singh, Lt. Governor of Goa, Daman & Diu, visited NIO on 22 January, 1985 accompanied by his wife Smt. Inderjit Kaur. Dr. V.V.R. Varadachari, Director, NIO received them and showed the various divisions and explained the activities of the Institute. Lt. Governor showed keen interest and was impressed with the research work being carried out.



A scientist explaining the working of the weather station (on model) installed at DAKSHIN GANGOTRI (Antarctica) to the Lt. Governor of Goa, Daman & Diu, Dr. Gopal Singh.

Other distinguished visitors were,

- Shri P.H. Pandian, Deputy Speaker, Tamil Nadu Assembly.
- Mrs. Vera Rich, Nature, London.
- Shri Mahmad Surti, Minister for Ports and Transport, Govt. of Gujarat.
- Dr. Hauns Child, Federal Ministry of Research & Technology, Germany.
- Dr. Dileep Patwardhan, American Centre, Bombay
- Prof. D.J. Crisp & Mrs. E.S. Crisp, Wales, U.K.
- Shri K.K. Mathur, Chief Secretary, Govt. of Goa, Daman & Diu.
- Dr. Tore Gjelsvik, Norsk Polar Institute, Norway
- Dr. S.P. Pandya, Physical Research Laboratory, Ahmedabad
- Dr. Aubert Michael, CNEXO, Paris.
- Brig. V. K. Saxena, National Defence College, New Delhi
- Major K. K. Sudan, National Defence College, New Delhi

- Dr. Hosal Emara, Qatar University.
- Prof. John B. Rose, Unesco, Paris.
- Shri M. Krishnamurthy, Govt. Food Department, Tamil Nadu.
- Prof. & Mrs. Olan Bevan, University of London, U.K.
- Dr. Lakshmi H. Kanta, Dynalysis of Princeton, Princeton.
- Shri. Pritam Singh. Central Water Commission, Ministry of Irrigation, New Delhi.
- Dr. Seewant Bhoojedhur, University of Mauritius.
- Dr. B.D. Tilak, Govt. of Maharashtra, Pune.
- Prof. C.S. Jha, Ministry of Education & Culture, New Delhi.
- Dr. Nityanand, Central Drug Research Institute, Lucknow.
- Prof. B. Ramachandra Rao, Member of Parliament, New Delhi.
- Shri K. Mohan Reddy, Member of Parliament, New Delhi.
- Shri B. Satyanarayan Reddy, Member of Parliament.
- Shri L.S. Swinj, Member of Parliament.
- Shri Shanti Tyagi, Member of Parliament.
- Shri R. Ramakrishnan, Member of Parliament, Madras.
- Shri S.S. Saxena, Govt. of Maharashtra, Bombay.
- Justice B.C. Gadgil, High Court, Bombay.
- Prof. B. Sheik Ali, Mangalore University.
- Prof. R.W. Fairbridge, Columbia University, New York.
- Prof. J.F. Riddell, U.K.
- Prof. S.J. Duda, Inst. of Geophysics, Hamburg.
- Dr. S. Aditya, K.D. Malaviya Inst. of Petroleum Exploration, Dehra Dun.
- Prof. Ajay K. Bose, Stevens Institute of Technology, U.S.A.
- Prof. G.J. Bakus, University of South California, U.S.A.
- Prof. Van Der Veen, Stevens Institute of Technology, U.S.A.
- Dr. Ahmed Meer. Science Counsellor, US Embassy.
- Shri A.C. Vadhavani, Director, Hindustan Zinc Ltd., Udaipur.
- Shri M.N. Balasahahry, Geological Survey of India, Calcutta.
- Dr. G. Roonwal, University of Delhi.
- Dr. B.E. Vijayam, Osmania University.
- Dr. A.K. Chatterjee, National Mineral Development Corporation, Hyderabad
- Dr. P.P. Vaidyaraman, CWPRS, Pune.
- Dr. Sharma, Central Electrical Authority, New Delhi.
- Dr. A.P. Rao, CRDL, HZL, Udaipur.
- Prof. Supriya Roy, Jadhavpur University, Calcutta.
- Shri R.J. Hemker, GMBH, Hamburg.
- Dr. H. Gundlach, Federal Institute of Geosciences & Natural Resources, FRG.
- Dr. Sheldon Breiner, EG & G, Geometries, U.S.A.
- Shri Ken Parolski, Ferranti ORE, U.S.A.
- Shri Jens Stephensen, Dwinger Marine Consultants, Denmark
- Shri Christian Soe, Dannerbury Yard, Denmark.
- Shri Karl Weber, GDR Embassy, New Delhi.
- S/Shri M. Aubert, S. Gregory, Grandvaux, C. Charles, H. Michel, P. Marchand, J. Lessain, J. Jarry and Gaptry. French CENEXO Experts.

- Dr. W.E.K. Warsi, Kuwait University.
- Dr. P.J. Curran, University of Sheffield. U.K.
- Shri A.R. Teissier, France.
- Prof. J. Makris, University of Hamburg, West Germany.
- Prof. Helmut Bruckner, Universitat Dusseldorf Geographisches Institute. West Germany.
- Prof. E.T. Degens, Geologisches Insitut der Universitat, Hamburg.
- Dr. Walter L. Pluger, Institute fur Mineralogie und legerstlenlehre der RWTM, Aachen.
- Dr. Ulrich Von Rod. Bundesanstalt fur Geoswissenschaften und Rohstaff. Hannover.
- Dr. Pascal Amanjean, President, M/s. Suber Co., France.
- Prof. A.K. Barua and Mrs. P. Chakrabarty of Bose Institute Calcutta.
- Dr. S.C.D. Sah. Director, Wadia Institute of Himalayan Geology. Dehradun.
- Dr. S.K. Biswas, General Manager, ONGC. Dehradun.

Visitors at Regional Centre, Cochin

- Dr. Sachiko Nagasamu, University of Tokyo. Japan.
- Dr. P. Krishna Rao, Satellite Applications Laboratory, U.S.A.
- Dr. M. Derkatch, Unesco Regional Office of Science & Technology for South and Central Asia, New Delhi.
- Dr. Kazuyoshi Hoseno, Yokosuka, Japan.
- Dr. Hiroyasu Otake, Hiratsuka, Japan.
- Dr. J.C. Jager, Biological Department, Free University. Amsterdam, Netherlands.
- Mrs. Madeleine Jacobs, Smithsonian Institution, Washington.

Visitors at Regional Centre. Bombay

- Dr. S.Z. Qasim, Department of Ocean Development. New Delhi.
- Dr. S. Varadarajan, D.G.S.I.R., New Delhi.
- Dr. G.S. Siddhu, Former D.G.S.I.R., New Delhi.
- Dr. Yuri M. Grachef, USSR Academy of Sciences, Moscow.
- Dr. Vladlen E. Artemyev, USSR Academy of Sciences, Moscow.

Visitors at Regional Centre, Waltair.

- Dr. D.S. Cronan, Imperial College of Science & Technology, London.
- Capt. P.I. Oomen, VMS Naval Oceanography & Meteorology, Cochin.

13

Colloquia

Date	Speaker	Subject
06.01.1984	Prof. J. Schewer University of Hawaii, U.S.A.	The pigments of deep-sea Gorgonians.
07.01.1984		Some aspects of chemical marine ecology.
11.1.1984	Dr. C.R. Narayanan, Indian Drug Research Laboratory, Pune.	Neem and its products.
18.1.1984	Prof. Roy Halliwell, Prof. D. Gareth Owen and Prof. G.S.W. King, U.K.	An overview of University Contributions in United Kingdom in Ocean research and develop- ments.
28.1.1984	Dr. Polly A. Penhale, National Science Foundation Washington, D.C. & Dr. Robert J. Orth, The Virginia Institute of Marine Science, The College of William and Mary, Virginia.	Seagrass communities in Chesapeake Bay. USA. An overview.
30.1.1984	Dr. Daniel E. Morse, University of California Santa Barbara, California.	Recent developments in mari- culture, marine fouling and bioactive substances.
09.02.1984	Mr. M. Singh, ECIL, Bombay.	Use of offline Floppy based data entry system DE5802.

20.02.1984	Prof. D. J. Crisp, Marine Sciences Laboratory, Wales, U.K.	Darwin's mistakes.
21.02.1984		A history of fouling and measures to combat it.
22.02.1984		The breeding of barnacles at different latitudes.
23.02.1984	Dr. J.R. Lewis, Welcome Marine Laboratory, University of Leeds, Yorkshire.	Spatial and temporal aspects of the distribution of rocky shore communities.
		PART I
24.02.1984		PART II
02.03.1984	Prof. Tore Gjelsvik, Polar Research Inst. Oslo, Norway.	Antarctic mineral resources with particular reference to the continental shelf.
05.03.1984		Polar sea ice.
15.03.1984	Prof. James Crease, Inst. of Oceanographic Sciences, Wormley, U.K.	Recent work at the Institute of Oceanographic Sciences, England.
16.03.1984	Dr. John B. Rose, UNESCO. Paris.	UNESCO activities in scientific and technological information.
19.03.1984	Shri R.N. Bhargava, Joint Advisor, CSIR.	Planning process in CSIR.
19.03.1984	Prof. A. Rehman, Director, NISTAD.	Science and society.
07.04.1984	Prof. E.A. Bevan, School of Biological Sciences, Queen Mary College, London.	Generical manipulation — old and new techniques.
13.07.1984	Dr. Paul Geerdens, UNESCO consultant.	An overview of the oceanographic research in the Netherlands.

17.07.1984		Information systems of an oceanographic data centre.
19.07.1984	Dr. Walter Koch, Graz, Austria.	Application of computerised information and documentation system
10.08.1984	Dr. P.J. Curran, University of Sheffield, U.K.	Remote sensing of the earth from space.
21.08.1984	Dr. W.E.K. Warsi, Kuwait University.	Convergence tectonics in the Peru Trench Region.
21.09.1984	Dr. Om Prakash, Central Drug Research Institute, Lucknow.	Application of NMR Spectroscopy in structural elucidation of bio-active substances.
19.10.1984	Dr. G.D. Floodgate, University College of North Wales, U.K.	Marine microbiological studies in North Wales.
31.10.1964	Shri Bhimsen Rao, Department of Ocean Development, New Delhi.	International law and marine scientific research.
29.11.1984	Dr. Robert George, University of North Carolina, U.S.A.	Biology of Antarctic Krill.
03.12.1984		Adaptations of deep sea animals
15.01.1985	Prof. A.K. Bose, Stevens Institute of Technology, Hoboken, New Jersey, U.S.A.	Newer techniques in mass spectrometry.
16.01.1985		Bioactive substances from the ocean.
10.02.1985	Dr. Pascal Amanjean, President, M/s. Suber Co., France.	Recent Development in Oceanographic Instrumentation.

14

Awards, Honours and Membership of Various Committees

Dr V.V.R. Varadachari

- Re-elected as the Vice Chairman of the Committee on Climatic Changes and the Ocean (CCCO) at its sixth Session held at Washington from 26 November to 4 December, 1984.
- Received the honorary D.Sc degree from Rani Durgavati Vishwavidyalaya, Jabalpur.
Elected fellow of National Academy of Sciences, Allahabad.
- Chairman of the Task Force on Remote Sensing in Oceanography, Marine Resources Management and Coastal Studies set up by Planning Commission.

Dr. T.S.S. Rao served as

- Member, Committee on Sea Aquarium. Govt. of Goa. Daman and Diu, Panjim-Goa.
- Member, Marine Biological Association of India.
 - Member, Fisheries Co-ordination Committee (Goa). Ministry of Agriculture, Govt. of India. New Delhi.
- Member, Editorial Board. Indian Journal of Marine Sciences, published by PID, CSIR. New Delhi.
- Adviser, Marine Ecology Progress Series, published by International Research. Federal Republic of Germany.
- Member, Board of Studies. Department of Life Sciences, Andhra University, Waltair.
- Member, Working Group on Western Ghats Eco-Development Research Programme, Department of Environment, Govt. of India, New Delhi.
- Member, Working Group on Department of Ocean Development Plan. Govt of India.
- Elected Fellow of the National Academy of Sciences, Allahabad.

Shri H.N. Siddiquie

- Continued to be as a member of the Commission on Marine Geology of the International Union of Geological Sciences.
- Continued to be as a member of the National Committee for the IUGG.
- Continued to be as a member of the Earth Science Committee of the INSA.
- Member of the Advisory Committee for Earth Sciences for Sir Shanti Swarup Bhatnagar Prize.
- Elected Vice-Chairman of Working Committee of Training, Education and Mutual Assistance (TEMA) of UNESCO.

- Elected Vice-Chairman for the Workshop on Improved uses of Research Vessels held at Portugal during 28 May to 2 June, 1984.
- Continued to serve as a member of Board of Studies in Marine Sciences, Geology and Marine Geology of Cochin. Bombay and Mangalore Universities.
- Continued to serve as a member of the Editorial Board for the Proceedings of the Indian Academy of Sciences (Earth and Planetary Sciences).
- Continued to be as a member of the Editorial Board for the Indian Journal of the Marine Sciences.
- Continued to serve as a member of the RAC of National Geophysic Research Institute, Hyderabad.
- Continued to serve as a member of the committee in the panel of Physico-chemical and Earth Sciences of Bureau of Promotion of Urdu, Ministry of Education, New Delhi.
- Elected Fellow of National Academy of Sciences, Allahabad.

Dr. B.N. Desai

- Elected Fellow of National Academy of Sciences, Allahabad.
- Member, Gujarat Science Academy.
- Member, Board of Studies, Central Institute of Fisheries Education, Bombay.
- Served as Expert, Selection Panel of Agricultural Sciences Recruitment Board.
- Managing Editor, Mahasagar.
- Member, Working Group for the Study of Bay of Bengal Fans, constituted by DST.
- Served as Member, Selection Board for Japanese Fellowship, Ministry of Education.
- Continued to serve as Member, Science and Technology Advisory Committee, Government of Maharashtra.
- Continued to serve as a Member, Advisory Committee, Water Pollution Prevention Board of Maharashtra.
- Continued as Member, Board of Studies in Environmental Pollution, University of Bombay.
- Continued to be Member, Bombay Metropolitan Regional Development Authority Advisory Panel.
- Continued as Member, State-level Committee on Fisheries. Government of Maharashtra.
- Continued to serve as Member, Expert Committee on Nhava Sheva Project.
- Member and Treasurer, Society for Offshore Engineering and Underwater Technology of India.
- Member, Indian Fisheries Association, Bombay.

Dr. J.S. Sastry served as

- Member, Indian Ocean Panel of CCCO of SCOR / IOC.

- Convenor of the Working Group for developing the observational programme on ocean atmosphere interaction and long term variability of the oceans under Indo-US collaboration programme on Monsoon Research.

Dr. R.Sen Gupta was

- Elected Fellow of the National Academy of Sciences, Allahabad.
- Member in the Task Force on procurement of polar research cum supply vessel (ice breaker) of Department of Ocean Development.
- Member of the study group of setting up of Antarctic study centre of Department of Ocean Development.
- Member of study group to workout detail requirements for Antarctic Study Centre of DOD.
- Member of the Committee on Control of Marine Pollution and Prevention of DOD.

Dr. M.G.A.P. Setty served as

- Member, Honorary Educational Advisory Board of the American Biographical Institute, Raleigh. U.S.A.

Dr. E. Desa served as

- Member, Department of Electronics, NRC Working Group on Sonars and Underwater Electronic Systems.
- Member, Project Review and Steering Group for Electronics Commission funded project on "Echosounders and Electromagnetic Speed Log".
- Member, Project Review and Steering Group for Manpower Development and Research in Underwater Electronics.
- Member, Technical Advisory Council, Economic Development Corporation of Goa, Daman and Diu.
- Member, Joint IOC/WMO Working Committee for IGOSS in the subgroup of experts on operations and technical applications.
- Member, Computer Society of India.

Shri P.S.N. Murthy

- Continued to be a member of the Special Committee for the School of Environmental Sciences. Jawaharlal Nehru University. New Delhi.

Shri L.V.G. Rao served as

- Member of ISI Hydrometer Sub-Committee CDS 33:3
- Alternate Member of ISI Marine Structures Sub-Committee BDC 39:9.
- Member of IODE/IOC Task Team on Ocean Data Management for Climatic Studies.
- Member of IODE/IOC Task Team on Measured Wave Data Management.
- Member of Indian Meteorological Society.

Shri S.P. Anand served as

- Member, Board of Studies in Oceanography, University of Cochin.

— Member, Board of Examiners in Oceanography for M.Sc. and M.Phil Degrees, University of Cochin.

Dr. R.V. Unnithan served as

— Member, Marine Biological Association- of U.K.

— Member, National Academy of Sciences, India.

— Member, Society of Fisheries Technologists (India).

Dr. V.N. Sankaranarayanan served as

— Member, Board of Studies, M.Sc. Mariculture, University of Cochin.

Dr. A.H. Parulekar served as

— Member, Committee for the Assessment of Environmental Issues of the Proposed Naval Base at Karwar, Department of Environment, Govt. of India.

— Member, Study Group on Setting up of Antarctic Study Centre, Department of Ocean Development, Govt. of India.

— Member, Expert Committee on Marine Fisheries, Govt. of Kerala.

— Expert Member, Board of Studies in Biosciences, University of Mangalore.

— Expert Member, Board of Studies in Zoology, Marine Biology and Fisheries, Shivaji University.

— Member, Study Group of Marine Resources Development. Govt. of Maharashtra.

— Chief Co-ordinator. IV Indian Scientific Expedition to Antarctica.

— Member, Board of Examiners in Marine Biology, Karnataka University.

Dr. M.D. Zingde served as

— Joint Secretary of the Society for Offshore Engineering and underwater Technology of India. Bombay.

— Member (alternate), Water & Effluent Subcommittee. CDC 26:3 of Indian Standards Institution, New Delhi.

Shri R.M.S. Bhargava continued to serve as

— Indian National Co-ordinator for International Oceanographic Data Exchange (IODE)/IOC of Unesco.

— Member, Group of Experts on Format Development of IODE.

— Member, Task Team on Marine Biological Data/IODE.

— Member, Task Team of Development of IODE Data Centre Services/IODE
The last three International teams were reconstituted by International Oceanographic Commission of Unesco, Paris.

Dr. A.G. Untawale served as

— Member, Beach Development Committee, Govt. of Goa, Daman and Diu.

— Member, Estuarine Development Committee, Govt. of Goa, Daman and Diu.

— Member, Expert Committee for the Institute of Mangrove Ecosystem Research, Department of Environment, Govt. of India, New Delhi.

- Member, National Mangrove Committee, Govt. of India, Dept. of Environment. New Delhi.
- Hon. Secretary, World Wildlife Fund (India) Goa Branch, Goa.
- Member, Wildlife Advisory Board, Govt. of Goa, Daman & Diu.
- Regional Task Force for Mangrove Ecosystem (UNESCO).

Shri. M.R. Nayak

- Fellow Member. I.E.T.E., New Delhi.
- Member, Computer Society of India.

Shri U.K. Gopalan served as

- Member of University-cum-Science and Technology Consultative Committee attached to All India Radio, Trivandrum Station.
- Member, Executive Committee of the Marine Biological Association of India.
- Member, Society of Fisheries Technologists, India.
- Member, Kerala Natural History Society.
- Member, Southern Regional Committee, World Wildlife Fund, India.
- Convener, Cochin Science Association.
- Member, Kerala Environment Council.
- Member, Agri-Horticultural Society, Cochin.

Dr. K.J. Peter served as

- Member of the Marine Biological Association of India.

Shri B. M. Panikkar served as

- Member, American Fisheries Society.
- Member, Marine Biological Association of India.

Shri D. Gopala Rao

- Member of the Post Graduate Board of Studies in Marine Geology, Mangalore University from 1984-87.

Shri V. Josanto served as

- Member, Central Contigent Plan Committee, Ministry of Transport, Bombay.

Shri G. Narayana Swamy

- Member, Executive Council, Society for Offshore Engineering & Underwater Technology of India.
- Co-Editor. SOSEUTI Bulletin.

Dr. Satish Shetye

Selected "Young Associate" by the Indian Academy of Sciences, Bangalore.

- Dr. (Mrs) Vijayalakshmi R. Nair served as
 — Member for Consultative Group, Fishery Survey of India, (Govt. of India), Bombay.
- Shri Aravindakshan served as
 — Member of the Marine Biological Association of India.
- Dr. T. Balachandran served as
 — Member of the Marine Biological Association of India.
- Dr. M.M. Sabnis served as
 — Member, Central Contigent Plan Committee, Ministry of Transport, Bombay.
- Dr. A.N. Kadam served as
 — Member, Central Contigent Plan Committee, Ministry of Transport, Bombay.
- Shri T. Balasubramanian
 — Member, Marine Biological Association of India.
- Shri P.S. Gore
 — Member, Society of Fisheries Technologists (India).
- Shri J.S. Sarupria Served as
 — Member, Computer Society of India.
- Shri O. Raveendran
 — Member, Society of Fisheries Technologists (India).
- Dr. S.M. Karisiddaiah
 Elected Fellow of the Geological Society of India.
- Shri D. Sengupta was
 — Awarded the Presidents (ISTAM) prize for his paper entitled "Scattering on Rossby waves of an irregular coastline" presented at the 29th Congress of the Indian Society of Theoretical and Applied Mechanics (ISTAM).
- Dr. V.K. Dhargalkar was
 Awarded the Jaycee State and National award for being one of the 10 outstanding persons of the year 1984 for spending one year in Antarctica and subsequent work.
- The following were awarded the degree of Ph.D.
- Shri S.N. De Souza was awarded Ph. D. Degree by the University of Bombay on the merit of the thesis entitled "Chemical characteristics of Mandovi and Zuari River System." The work was carried out under the guidance of Dr. R. Sen Gupta.
- Mrs. Solimabi Wahidulla was awarded Ph. D. Degree by the University of Bombay on the merit of the thesis entitled "Structure and reaction of some naturally occurring terpenoids" under the guidance of Dr. S.K. Paknikar.
- Shri G.V. Rajamanickam for his thesis entitled "Geological investigations of offshore heavy mineral placers of Konkan Coast, Maharashtra, India" by Indian School of Mines, Dhanbad.

- Shri Madhusudan Rao CH. was awarded Ph.D. Degree for his thesis entitled "Geochemistry of the sediments of Central Western Continental Shelf of India" by Andhra University. Waltair.
- Shri A.L. Paropkari was awarded Ph.D. Degree for his thesis entitled "Geochemical Studies of the shelf and upper slope sediments off Mangalore-Cochin. Western Continental Margin of India" by Indian Institute of Technology. Bombay.
- Shri S.S.C. Shenoi has been awarded Ph.D. Degree by Cochin University in Physical Oceanography in November. 1984 for his thesis entitled "Studies on the littoral process in relation to stability of the beaches around Cochin."
- Shri X.N. Verlekar for his thesis entitled "Nutrients and Organic Production in Tropical Coastal Ecosystems" by the Bombay University.
- Shri S.N. Harkantra for his thesis entitled "Studies on the Intertidal Ecology of Sand Dwelling Benthic Communities" by Karnataka University.
- Shri C.L. Rodrigues for his thesis on "Community Structure of Intertidal Fauna at Dona Pau Beach (Goa. India)" by Poona University.
- Shri C. T. Achuthankutty for his thesis entitled "Studies on some commercially important penaeid prawns along the Goa Coast" by the Bombay University.
- Shri P. Haridas was awarded Ph.D. degree by the University of Cochin for his thesis entitled "Zooplankton Studies in the Cochin Environs."
- Shri P.V. Shirodkar was awarded Ph.D. degree by the University of Bombay on the merit of his thesis entitled "Behaviour of Boron and related parameters in the Mandovi river estuary (Goa)".

15 Deputations

Dr. V.V.R. Varadachari was deputed to

- France, to attend the 17th Session of the Executive Council of the Intergovernmental Oceanographic Commission (IOC), held at UNESCO, Paris, from 31 January to 9 February, 1984.
- U.S.S.R., to attend the meeting of the officers of the Committee on Climatic Changes and the Ocean, held at Moscow from 3 to 5 July, 1984.
- U.S.A., to attend the officers meeting and the 6th Session of the Committee on Climatic Changes and the Ocean, held at the National Academy of Sciences, Washington, from 26 November to 4 December, 1984.
- France, to attend the 13th Session of the Intergovernmental Oceanographic Commission (IOC) from 18-29 March, 1985.

Dr. T.S.S. Rao was deputed to

- Chicago, U.S.A., in September, 1984 to attend the Scientific Review Committee for organizing the International Conference on Biogeography in Amsterdam in 1985.

Shri. H.N. Siddiquie was deputed to

- Lisbon, Portugal to attend the IOC/UNESCO Workshop on Improved uses of Research Vessels and the Fourth Session of the Working Committee for TEMA from 28 May to 8 June, 1984.
- Paris, France, to attend the Preliminary expert consultancy at the IOC/UNESCO (Paris) on the preparation of a guide on Operational and Management of Research Vessels and related training from 14 October, 1984.
- Paris, to attend the meeting of the First Session of the IOC (OETB) Guiding Group of Experts on the Programme of Ocean Science in relation to Non-living Resources at Unesco office from 14-18 January, 1985.

Dr. R. Sen Gupta was deputed to Brussels from 5-6 July, 1984 as an invited expert to attend the meeting of Scientific Advisory Committee on Ecotoxicology of SCOPE of ICSU.

Dr. M.G.A.P. Setty was deputed to

- Australia, from 13-17 August, 1984 to participate in the International Symposium on Biological Research of Vestfold Hills, Antarctica held at Kingston, Tasmania.

Dr. E. Desa, Dr. E.S. Desa and Shri Eurico D'Sa, attended a course on "Image Processing Techniques" at I.I.T., Kharagpur from 12.8.1984 to 18.8.1984.

- Dr. E. Desa, attended the Instrument Technology Course conducted by the Institution of Engineers (India) in collaboration with the British High Commission at Bombay from 12.9.1984 to 22.9.1984.
- Shri R.M.S. Bhargava was deputed for a Workshop on Scholarly Communication in Science and Technology held at PID, New Delhi from 18-27 March, 1985.
- Dr. A.G. Untawale was deputed to
- James Cook University, Townsville, Australia, as a "Resource Person" to the training course on "Marine Algal Resource Survey and Methodologies", sponsored by Commonwealth Secretariat, London, from 7 to 21 May, 1984.
 - Bogor, Indonesia and represented India in the Regional Task Force meeting on mangrove ecosystem, sponsored by UNESCO from 8 to 10 October, 1984.
- Dr. A.G. Untawale and Shri T.G. Jagtap were deputed to the Republic of Seychelles for undertaking the seaweed resource survey from February 19 to April 12, 1984.
- Shri V.P. Devassy was deputed to Sydney (Australia) in response to the invitation from the Association for Science Co-operation in Asia to participate and present paper on "Red Tide Phenomena" from 18 to 20 June, 1984.
- Dr. S.C. Goswami was deputed to Shimizu, Japan from July 22 to August 10, 1984 to attend the International Symposium on Marine Plankton at Tokai University and to study CSK Plankton samples at the Marine Biological Research Centre, Orido, Shimizu, Japan.
- Dr. A. Rajendran was deputed to Netherlands Institute for Sea Research, the Netherlands under UNESCO fellowship from 27 December 1984 for a period of one year.
- Dr. N. Bahulayan and Shri Sukomal Mandal were deputed to Netherlands and Norway for advanced training and development of wave hind casting model for the Indian Coasts under the ongoing NORAD Project from November, 1984 to March, 1985.
- Dr. Satish R. Shetye was deputed to Joint Institute of Marine and Atmospheric Research, University of Hawaii, Honolulu from 1 to 29 October, 1984 under INDO-US cooperation programme on monsoon research.
- Dr. (Miss) Shubha Sathyendranath was deputed to Canada to attend the International Conference on Ecosystem Theory in relation to Biological Oceanography from 16 to 23 March, 1984.
- S/Shri Prabhudev Desai and Eurico D'Sa were deputed to Benson Co., France from 15.3.1984 to 12.4.1984, to undergo training on Benson Plotter, Digitizer and Magnetic Tape Drive.
- Mrs. Solimabi Wahidulla and Mrs. B. Das were deputed for training in preliminary bioassay testing in pharmacology. CDRI, Lucknow from 3 March to 1 April, 1984.
- Dr. C.G. Naik, S/Shri S.W.A. Naqvi, P.S. Parameswaran, Joaquim Goes and T.G. Jagtap were deputed for a diving course at Naval Establishment, Cochin from August to October, 1984.
- Dr. C. G. Naik S/Shri S.W.A. Naqvi, Joaquim Goes and T.G. Jagtap were deputed to the Department of Biological Sciences, University of California, Los

- Angeles. U.S.A. for advanced course in diving and species diversity under the Indo-US Collaborative Project from 18 November, 1984 to 18 February, 1985.
- Miss Sujata Sanzgiri was deputed to Institute of Analytical and Marine Chemistry, Sweden from October, 1984 on a 9 month advanced training course in marine pollution.
- Shri A. Suryanarayana was deputed to Poland from 8 June to 30 August, 1984 under CSIR-PAS Exchange Programme.
- Shri M. R. Ramesh Kumar was deputed from July 23, 1984 for a ten week training programme in computerised image processing system for meteorological observations at Computer Maintenance Centre, Hyderabad.
- Shri G. Banerjee was deputed for training programme in Patents, held at Calcutta from 25 to 27 April, 1984.
- Shri P.S. Parameswaran attended the training on FT-IR and Laser Raman Spectroscopy organised by the IIT, Bombay from 15 to 17 November, 1984.
- Dr. T.V. Ramana Murthy was deputed to "Short term course on Digital Image Processing" from 12 to 16 June, 1984 held at Department of Electronics and Electrical Communications Engineering, IIT, Kharagpur.
- Shri S. G. Prabhu Matondkar was deputed to be a Member of IIIrd Indian Antarctic Expedition - Winterization party from November 1983 to March 1985.
- Dr. V. K. Dhargalkar was deputed by CSIR and DOD for winterization training programme at Davis, Australian National Antarctic Research Expedition from 5 February, 1983 to 13 June, 1984.
- Shri B. S. Ingole was deputed from December, 1984 to March, 1985 as a member of summer team of IVth Indian scientific Expedition to Antarctica.
- Dr. X. N. Verlencar was deputed from December 1984 to March 1986 as a member of Winterization team of IVth Indian Scientific Expedition to Antarctica.
- Shri K. Aravind Ghosh was deputed to Denmark for training in computer software to develop programmes for the collection and processing of oceanographic data on board FORV. **Sagar Sampada** under DANIDA Programme from 15 August to 26 November, 1984.
- Shri P. J. Pawaskar was deputed to NAL, Bangalore for draftsman training from 11 to 20 October, 1984.
- Shri Anil V. Sirgaonkar was deputed to I.I.T. Bombay for fibre glass training from 27 to 30 November, 1984.
- Miss Prabha Gore was deputed to Survey Training Institute of Survey of India, Hyderabad, for a training course in Cartography from 10 October to 7 December, 1984.

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Participation in Seminars, Symposia and Exhibitions

- Dr. T.S.S. Rao attended a National Symposium on "Oceans : realities and prospects" at New Delhi, during March, 1984.
- Dr. H.N Siddiquie attended National Seminar on Sub-sea Technology and Mineral Development, held at Visakhapatnam from February 23-25, 1984.
- S/Shri H.N. Siddiquie, V.P.C. Rao, Rahul Sharma, R. Mukhopadhyay, M. Sudhakar, J.M. Pattan and Miss Pratima Jauhri participated in the National Seminar on the processing of manganese nodules at RRL, Bhubhaneswar from February 28 to March 1, 1985.
- S/Shri H.N. Siddiquie, P.S. Rao and A.V. Mudholkar presented a paper "Marine Geosciences in the Indian Ocean - possible approaches for collaboration in the programme for ocean science and non-living resources" at the OSNLR Conference held at Paris during December, 1984.
- Shri H. N. Siddiquie attended a workshop "Working group on Metallurgy for Polymetallic Nodules" at Visakhapatnam, from 6-7 April, 1984.
- S/Shri H.N. Siddiquie, N.H. Hashmi and A.R. Gujar presented a paper "Research Vessels in India - a case study in cruise planning and utilization", in IOC/FAO Workshop on improved uses of research vessels organised in co-operation with NORAD, Lisbon, Portugal, 28th May - 2nd June, 1984.
- Shri H.N. Siddiquie delivered a lecture on the First Indian Expedition to Antarctica at Aligarh Muslim University, on 3 May, 1984.
- Dr. B.N. Desai presented a paper "Changing Ecology of Our Coastline" at the Gujarat Science Academy in December. 1984.
- Dr. J.S. Sastry, Shri L.V.G. Rao, Dr. (Miss) Shubha Satyendranath. Dr. Satish R. Shetye and Shri V. Ramesh Babu participated in INDO-US Workshop on Ocean Atmosphere Interaction held at the Indian Institute of Science, Bangalore from 9-13 April, 1984.
- Dr. J.S. Sastry chaired a session in the National Acoustic convention at IIT, Kharagpur. from 10-12 December, 1984.
- Dr. R. Sen Gupta delivered lectures at the seminar on Marine Pollution organised by Ministry of Shipping and Transport and International Maritime Organisation, held at NITIE, Bombay, from 8-13 October, 1984.
- Dr. B.U. Nayak presented an invited paper on "The role of oceans in the economic growth of India and the need for self-reliance in Marine Technology", at the Institution of Engineers (India), Goa Sub Centre, Panaji, in September, 1984.
- Dr. B.U. Nayak delivered a lecture on "Some salient aspects of construction, installation and maintenance of marine outfalls" at Central Board for the Prevention and Control of Water Pollution, Bombay in January 1985.

- Dr. M.G.A.P. Setty and Shri R. Nigam presented a paper "Benthic foraminifera as indices of diversity and hyposalinity in modern clastic shelf regime off Bombay" at the Intern. Symp. *Shallow Water Invertebrates of Indian Ocean* held at Marathwada Univ., Aurangabad from 20-24 January, 1984.
- Dr. M.G.A.P. Setty delivered a series of four lectures on marine paleontological aspects at the Department of Geological Sciences, University of Roorkee, Roorkee, in February. 1984.
- Dr. E. Desa presented a paper "Unmanned stations in Antarctica" at the National Symposium on growing focus on Antarctica, held at New Delhi from 17-18 October 1984.
- Dr. E. Desa and Shri M.R. Nayak presented a paper "Marine Instrumentation - a review", at the National Conference on Electronics, held at CEERI, Pilani, in October. 1984.
- Shri. P.S.N. Murthy delivered a series of invited lectures on Oceanography in general and Marine Geology in particular at Dhempe College of Art & Science, Panaji, during November - December, 1984.
- Shri L.V.G. Rao participated in the following workshops:
- "INDO-FRG Workshop on Marine Sciences" held at NIO, Goa from 26-31 October. 1984.
 - "INDO-FRC Co-operation Programme for the Propagation and Promotion of Advanced Remote Sensing in India" held at National Remote Sensing Agency, Hyderabad, from April 30 - May 1, 1984.
- Dr. R.V. Unnithan presented a paper "Retting of coconut husk as a source of organic pollution in Cochin backwaters" at the seminar on Pollution Problems held at FACT, Ambalamukal, on 5 April, 1984.
- Dr. A.H. Parulekar presented the following papers:
- "Long Term Variations in Benthic Macroinvertebrate Assemblages off Bombay" at the International Conference on Biology of the Benthic Organisms at Aurangabad. 20-24 January. 1984.
 - "Benthic Watch: A case study of Biological Monitoring on Marine Environment", at the first Indian Conference on Applied Biology in Human Health and Environment, at Lucknow, February. 13-15. 1984.
 - "Benthic Explorations and Potential Demersal Fishery Resources of the Indian Ocean", at the National Symposium, "The Oceans: Realities and Prospects", at New Delhi. 26-28 March, 1984.
 - "Antarctic Biology - Indian Contributions & Perspectives" at First National Symposium on Growing Focus on Antarctica, New Delhi, 17-18 October, 1984.
 - "Role of water quality in sea farming", at the seminar on sea water quality demands organised by Naval Chemical and Metallurgical Laboratory and Defence Science Organisation held at Bombay, from February 20-21, 1985 and also chaired the session on "Oil Pollution."
 - "Environmental Impact on Mining Activities on Estuarine Shell Fisheries of Goa" at the workshop of Working Group on Western Ghats held at Panaji, Goa from 20-21 July. 1984.

- Dr. A. H. Parulekar delivered the following lectures:
- "Biology of important commercial species of fish and shellfish" at the training programme on Fishery for Technologists/Supervisors organised by Export Inspection Agency, at NIO, Goa.
 - "Technical and Economic aspects of mariculture" at the training course on Fisheries Development through Institutional Finance at CIFE, Bombay.
- Dr. M.D. Zingde presented a paper on "Waste water effluents and coastal marine environments of Bombay" at the seminar on Sea water quality demands organised by Naval Chemical and Metallurgical Laboratory Bombay from 20-21 February, 1985.
- Shri M.R. Nayak presented a paper "Satellite Communication from Antarctica" at the National Symposium on Growing Focus on Antarctica, held at New Delhi, from 17-18 October, 1984
- Shri. U.K. Gopalan delivered the following lectures:
- "Fisheries conservation in Kerala" at Maharaja's College Ernakulam on 3 August, 1984.
 - "Estuarine ecosystem and manmade alterations in Kerala" to the UNESCO trainees on Mangrove Ecosystem, at NIO Regional Centre on 14 November 1984.
- Shri V. Josanto and Dr. B.N. Desai presented a paper "Waste water disposal in coastal waters - a case study," at National Symposium on "The Oceans: Realities and Prospects", at New Delhi, 26-28 March, 1984.
- Dr. P.S. Renukaradhya delivered a lecture on "The wave drift force on offshore structures" at the 29th Congress of the Indian Society of Theoretical and Applied Mechanics held at KRE College, Suratkal, Karnataka in December, 1984.
- Shri G. Narayana Swamy presented a paper on "Physical oceanographic investigations required to decide length and alignment of marine outfalls" at the National Workshop on Marine Outfall held at Panaji, from 26-28 April, 1984.
- Dr. E.S. Desa and Mrs. V.B. Peshwe attended a seminar on "Analog Circuit Design and Data Conversion Techniques" organised by M/s. Analog Devices, U.S.A. at Bangalore on 7 December, 1984.
- Dr. E.S. Desa, Shri Eurico D'Sa and Shri T. Suresh attended a seminar on "Computer Systems and Signal Processing" conducted by I.E.E.E. at Bangalore from 9-13 December. 1984.
- Dr. N. Bahulayan participated in the National Symposium on "The oceans - realities and prospects", held at the India, International Centre, New Delhi from March 26-28. 1984 and presented a paper on "Modelling of oceanic processes with special reference to Indian Ocean: Some problems and prospects."
- Dr. N. Bahulayan participated in the National Workshop on "Longterm variability

- on monsoons", held at India Meteorological Department, Pune. from 26-28 September, 1984.
- Dr. R.A. Selvakumar attended the International Symposium on Biological Monitoring of the State of the Environment (BIOINDICATORS) at the Indian National Science Academy at New Delhi.
- Smt. C.B. Lalithambika Devi participated in the seminar on "Development and Eco-system" organised by Society for Ecological Conservation and Development, at Cochin on 5 June, 1984.
- Shri K. Govindan presented a paper on "The effect of disposal of effluents on marine ecology" at the National Workshop on Marine Outfall held at Panaji, from 26-28 April, 1984.
- Dr. T. Balachandran delivered a lecture on "Contamination of drinking water by human enteric parasites" to the trainees — NEERI organised training programme for public health engineers all over India at Department of Marine Sciences, University of Cochin on 20 May. 1984.
- Shri P.S. Gore presented a paper entitled "Seawage contamination of Moplah Beach at Cannanore" at the Seminar on "Pollution Problems" held at FACT, Ambalamukal, on 5 April, 1984.
- Presented a paper entitled "Monitoring coastal environs" by R.V. Unnithan. P.S. Gore and P. Venugopal at the seminar on Environmental Education organised by Lakshadweep Administration from March 22-26. 1985 and gave a lecture.
- Shri L.V. Subba Raju, K.A. Kamesh Raju, V Subrahmanyam and D. Gopala Rao presented a paper "Regional gravity and magnetic studies on the continental margin between Bombay and Ratnagiri (India)" at the seminar on Association of Exploration Geophysics held at Hyderabad in October. 1984.
- Shri V. Ramesh Babu participated in National Workshop on "Numerical Weather Prediction" held at India Meteorological Department, New Delhi from 2 July - 4 August, 1984.
- Shri Rajiv Nigam participated and presented a paper "Foraminifera as indicator of sediment movement, a study in shelf region off Navapur. India" at 71st Indian Science Congress, Ranchi from 3-8 January, 1984.
- Participated and presented a paper "Dimorphic form of foraminifera: an additional tool in paleoclimatic studies" at XIth Indian Colloquium on micropaleontology and stratigraphy. Calcutta from 16-18 October, 1984
- At the second National Seminar on Marine Intertidal Ecology organised by Andhra University. Waltair from February 14-16, 1985, the following papers were presented:
- S.N. Gajbhiye, Vijayalakshmi Nair, R. and Desai. B. N. "Zooplankton biomass and population along the nearshore waters off Bombay."
 - S.N. Gajbhiye, Vijayalakshmi Nair. R. and Desai, B.N. "Diurnal variation of zooplankton in the polluted environments off Bombay."
 - M. Jiyalal Ram, Vijayalakshmi Nair, R. and Desai, B.N. "Chlorophyll and phytoplankton diversity in the nearshore waters of Mithapur (Gulf of Kutch)"

- d) V. Josanto, Sarma, R .V., Vijayakumar. CV. and Prasad. A.L. "Hydrographic studies for an all weather port at Dabhol Creek."
- e) M. Jacob, Shankar. L.U. and Jayachandran. R. "Hydrography of Sutrapada coast in relation to cooling requirements of a soda ash factory."
- f) V. Josanto, Sarma. RV. and Vijayakumar, CV. "Waste water disposal in Tapi estuary".

Dr. S.N. Harkantra presented the following papers at the International conference on Biology of the Benthic Organisms, at Aurangabad. 20-24 January. 1984:

- "Intertidal benthic community ecology of sand dwelling macroinvertebrates of Goa beaches."
- "Long term variations in benthic macroinvertebrate assemblages off Bombay."
- "Population ecology of meio-fauna taxa in a sandy intertidal region" and "Community structure of a sandy intertidal macro-benthic fauna" at the second National Seminar on Marine Intertidal Ecology hold at Andhra University during February 14-16. 1985.

Shri M.V. Ramana., B. Rajendraprasad and R.D. Hansen presented a paper "Geological and geophysical studies of error seamount" at Decennial Conv. & Sem. Exploration Geophysics, held at Hyderabad.

Shri D.V. Rama Raju presented a paper in a National Symposium "Growing Focus on Antarctica" held at New Delhi, from 17-18 October, 1984.

Shri. S.R. Sreekumaran Nair and Shri Z. A. Ansari presented a paper "Possible effects on the marine life due to deep sea mining in Indian Ocean" at the Seminar on Environmental aspects of Geology. 26-28 November. 1984 at Trivandrum.

S/Shri T. Ramaprasad and A.K. Chaubey attended the International Workshop on Data Processing for developing countries at Pune from February 25 to March 9, 1985 organised under the auspices of International Commission on developing countries (International Association of Geomagnetism & Aeronomy).

Shri S.J.D. Vara Prasad and Shri G. Banerjee represented NIO pavilion at the Trade and Industries Fair organised by the Ex-services League held at Pune from 10 April to 31 May. 1984.

Shri S.J.D. Vara Prasad. Shri G. Banerjee and Shri RM.S. Bhargava participated in the India International Trade Fair organised by the Trade Fair Authority of India held at New Delhi from 14-27 November. 1984.

Dr. A.N. Kadam attended a workshop on "Gas chromatography column packing methods" organised by Kalpavriksha Enterprises, Bombay from 10-11 December. 1984.

Dr. V.K. Dhargalkar presented the following papers:

- "Benthic marine algae from Eastern Antarctica" and "Animal association with dominant species of shallow water macrophytes along the coastline of the Vestfold Hills. Antarctica" at the Vestfold Hills Symposium held at Antarctic Division, Tasmania. Australia from 10-14 August. 1984

— "Some observations on the biota of the Vestfold Hills" at the Symposium on Growing Focus on Antarctica held at JNU, New Delhi from 17-18 October, 1984.

Shri D. Sen Gupta attended the 29th Congress of the Indian Society for theoretical and applied mechanics held at Suratkal in December, 1984.

S/Shri T. Jagtap and Joaquim Goes attended symposium on "Biologically active substances from the ocean" at Stevens Institute of Technology, Hoboken, New Jersey on 6 February, 1985.

Shri G. Nampoothiri participated in the Workshop-cum-Seminar on "Acoustic Releases" held at Central Water and Power Research Station, Pune in October, 1984.

Workshop on R & D Management for the Project

"SURVEYS FOR POLYMETALLIC NODULES" seven day workshop on R & D management for poly metallic nodules was organised in collaboration with the Centre for Management Development, NISTADS, New Delhi, from October 8-15. Dr. V.V.R. Varadachari, Director, NIO inaugurated the Workshop. Everyday 3-4 sessions were held covering different aspects of management. Experts from NISTADS (6 scientists) and other organisation (5 scientists) discussed various topics such as Technological Forecasting, Project Planning, Management Innovation, Infrastructure, Project Cost and Accounting, Operational Planning, Social Cost Benefit Analysis and Group Dynamics. The workshop was found very useful by all the participants.

Course on Administrative Management in R & D at NIO

The 8th course on Administrative Management in Research and Development was held at NIO from 19 March to 3 April, 1984. This course was organised under the auspices of the Centre for Management in R & D of National Institute of Sciences, Technology and Development Studies (NISTADS), CSIR, New Delhi. About 40 Private Secretaries and other administrative personnel from 30 national laboratories under CSIR, participated in the course. The course, in general, was aimed at equipping these officers to perceive their functional objectives and match the same with the totality of the system so as to provide an ideal administrative support to R & D in CSIR.

In his inaugural address Shri K.K. Mathur, IAS, Chief Secretary, Govt. of Goa, Daman & Diu, said good administration is particularly important for R & D activities because most of the activities require a fine tuning in regard to time and any delay in making available materials, equipment and personnel, adversely affect their progress and also scientists like most other persons of high intellect are sensitive people and they can feel greatly disturbed and lose their initiative and creativity if good administrative support is not given to them at all stages and if their genuine personal matters are not given due attention. Prof. A. Rehman, Director, NISTADS who also spoke on the occasion stressed the need for humanitarian approach in administrative management. Dr. V.V.R. Varadachari, Director, NIO welcomed the guests.

During the valedictory function held on 3 April, 1984, Dr. V.V.R. Varadachari distributed the certificates to the participants.



Shri K.K. Mathur, Chief Secretary, Govt. of Goa, Daman & Diu inaugurating 8th course on Administrative Management held at NIO.

Observation of Hindi Day

NIO organised a Hindi Workshop on 22 March, 1985 in collaboration with CSIR Headquarters. This was followed by celebration of Hindi Day on 23 March, 1985. On this occasion competitions in hand writing, elocution and reading were held and prizes were distributed to the winners of competitions.

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