

RESEARCH VESSELS IN INDIA
- A CASE STUDY IN CRUISE
PLANNING AND UTILISATION

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INTRODUCTION

Research vessels are an essential tool for marine research and therefore an important component of marine research programmes and institutes. Since the cost of operation of the research vessels is very high, the vessel account in many cases forms a substantial part of the budget of marine research institutes. Proper planning of cruise programmes and the optimum utilization of the vessels is therefore important to ensure optimum utilization of the available resources.

In the present study, the term research vessel is not restricted to only the vessels specially designed and built for research, but also includes vessels converted for research and those chartered for short-term and fitted with suitable equipment for research. A variety of jobs near the coast can be effectively and economically carried out by smaller vessels (about 15 m length) and these are also covered in this study.

The present paper is based on the study of the performance of the research vessels owned or chartered by the Council of Scientific and Industrial Research and the Department of Ocean Development. The authors because of their specialization have paid greater attention in the present study to the utilization of vessels for marine geosciences and marine mineral exploration.

RESEARCH VESSELS IN INDIA

Marine research in India was initiated in 1875 on the Royal Indian Marine Survey's vessel (Sewell, 1938). RIMS INVESTIGATOR was perhaps one of the first vessels to carry out marine research in the Indian waters (Fig. 1). The scientists on the vessel carried out the pioneering work on the waters, geomorphology and sediments of the Bay of Bengal (Carpenter, 1885, 1887; Sewell, 1937) and the Arabian Sea (Oldham, 1895) and reported the occurrence of barium nodules (Jones, 1887, 1888) and phosphorite concretions (Tipper, 1911) from the Indian continental margin. These studies were a landmark for the period and provided the basic data for future work.

After these pioneering efforts, there was a considerable pause and oceanographic studies in the country were only renewed in the early 1950's when the Oceanography Department of the Andhra University was formed. The work was then largely carried out on naval vessels INS KONKAN, MADRAS, BENGAL, RAJPUTANA, ROHILKHAND and CIRCARS.

India played a significant role among the countries of the region in the International Indian Ocean Expedition (1959 to 1965). In the expedition, the Indian scientific programme was largely carried out on Indian naval vessel KISTNA and to a lesser extent on RV VARUNA, RV CONCH and FV BANGADA.

The International Indian Ocean Expedition developed a cadre of trained marine scientists in the country, generated interest in the Indian public and scientific community in oceanographic research and the resources of the oceans. The formation of the National Institute of Oceanography is perhaps a sequel to the expedition. In the post-IIOE period, the absence of research vessels proved to be a serious handicap for the trained marine scientists in the country. The gap was filled to some extent by the cruises organized by the Indian Naval Hydrographic Office in 1973-74 on INS DARSHAK. These cruises generated a wide variety and large volume of data on the physics, chemistry, biology and geology of the north-eastern Arabian Sea and the north-western continental margin of India.

In the 1960s, the need for the exploration and exploitation of the food resources of the sea for the rising population of the country was felt. This led to the development of facilities for the exploration and exploitation of the living resources, and programmes for the modernization of the fishing industry. As a part of this programme, institutions were developed and fisheries research vessels acquired, and bases built at Indian ports. During this period, the Oil and Natural Gas Commission and the Geological Survey of India initiated the planning and, to some extent, programmes to extend the exploration for oil and minerals and geological mapping offshore.

The 1970s marked an increasing interest in the oceans, but the period was largely devoted to the development of infrastructure and the creation of facilities for marine research work. The Council of Scientific and Industrial Research (National Institute of Oceanography) acquired a hopper barge and the Garden Reach Ship Builders, Calcutta, converted this to R.V. GAVESHANI. This was the first multi-disciplinary oceanographic research vessel in India and formed a useful platform for the training of Indian scientists, which was essential for providing the manpower for the increased activities in the 1980s. The 1970s also witnessed a steep rise in the price of oil and, with the increased import bill, the exploration of offshore areas for oil was taken up. The Oil and Natural Gas Commission during this period acquired the seismic vessel ANVESHAK.

The increased interest in the resources of the ocean, the deliberations at the Third Session of the UN Conference on the Law of the Sea, the Large Exclusive Economic Zone and the proposed International Area provided an impetus to marine research in India. The expeditions to the Antarctica and the Surveys for Polymetallic Nodules are perhaps the result of the increased interest in marine research. It was realised that, by this time, the country had the

trained manpower, but to meet the time targets and possibly to narrow the gap with other countries in the field, it would be advantageous to charter vessels for Antarctic research and Surveys for Polymetallic Nodules. A vessel is now regularly chartered for the expeditions to the Antarctic and two vessels were chartered for the Surveys for Polymetallic Nodules. The new oceanographic research vessel SAGAR KANYA was received from West Germany in 1983 and negotiations with Denmark for a fisheries oceanographic research vessel SAGAR SAMPADA were finalized. The Indian research vessels (including those chartered) provided about 100 berths at a time for scientific research (Table I). The area of operation of these vessels covers the Arabian Sea, Bay of Bengal, central Indian Ocean, and the Antarctic waters. The vessels are also being used for collaborative programmes with Seychelles, Sri Lanka and Mauritius.

MANAGEMENT OF CRUISE PROGRAMMES AND RESEARCH VESSELS

RESEARCH CRUISE PLANNING

Planning for cruises is the first step towards the optimal utilization of the research vessels and in India annual cruise plans are prepared initially at the National Institute of Oceanography (disciplinary/divisional levels, Figs. 2 and 3). Subsequently, these are reviewed at an Inter-Agency Workshop (living resources, non-living resources and environment, Fig. 4). The Inter-Agency Workshop provides a useful forum for scientists of same and different disciplines to draw common programmes and build linkages between the institutional and interdisciplinary programmes. The national committee ensures that the programmes are within the priorities assigned to different sectors and duplication is avoided.

MANAGEMENT OF CRUISES

The cruises are operated under two categories: the individual institutional and multi-institutional. The multi-institutional cruises require co-ordination between different organizations, the co-ordination is usually carried out by a Project Co-ordinator from the discipline.

The operation of the scientific programmes has two components: the manpower (scientists and technicians) and equipment. The operation of the scientific programmes or collection of data and samples by the scientists does not pose any problems since the country now has sufficient expertise and manpower. However, problems were initially faced in the training of the technicians and engineers as the technology in the field advances faster and the engineers/technicians are required to be trained for every new equipment. The Institute has adopted an approach that equipment for which service and maintenance facilities are available in the country will be serviced and repaired in the port by the manufacturers' representa-

tives. Equipment for which facilities are not available in the country and which has to be operated continuously on the cruise will be maintained and serviced by the Institute's personnel. The assigning of a priority to the training of the engineers and technicians and linking the training with the acquisition of the equipment and vessels has improved the situation considerably.

In 1982-84, over 40 scientists, engineers and technicians were trained abroad in various aspects of marine science and instrumentation.

The Institute, during the last few years, has operated many programmes. One of the priority and time-targeted programmes was for the Surveys for Polymetallic Nodules. The analysis of man-days (scientists, engineers and technicians) in the laboratory and on the vessel (Figs. 5 and 6) shows that a ratio of 1 (ship): 3 (laboratory) causes a strain for cruises of 45 days duration and it was felt that an ideal ratio would be 4 or 5. The development of manpower therefore has been assigned a high priority because of the need for the operation of the vessels and equipment round the clock.

Since many teaching institutes do not have research vessels, facilities for training are extended liberally on the research vessels. The Council of Scientific and Industrial Research provides the passage and free stay of the students and teachers on research vessels, and the Department of Ocean Development has given over a hundred fellowships under the Marine Research Development Fund. The facilities enable the students and teachers from a number of universities to work on ships and thus create a wider base of scientific manpower for future expansion of activities. It is estimated that, during 1982-84, over 38 teachers and students have participated in the cruise programmes and two short cruises of RV GAVESHANI were specifically arranged for training of university teachers and students. The total manpower in marine sciences in the country is about 950 (1981) but most of this is not available for ship-board work.

OPERATION OF THE VESSELS

The operation of the research vessels, excluding the chartered vessels, has been entrusted to the Shipping Corporation of India. The Shipping Corporation of India, a government agency, has a fleet of about 150 vessels. The operation of the vessels by the Shipping Corporation of India reduces the Institute's problems considerably in the matter of rotation of officers and crew and logistic support for the vessel at various Indian and foreign ports. The system has worked satisfactorily for the last few years. The chartering of vessels further reduces the problems for a

research Institute in cruise management; this may not be possible for all projects and institutes but such an approach needs to be examined and encouraged. The growth of a fleet of supply vessels (for the offshore oil industry) and of research vessels in India has led to the formation of a number of shipping companies (though smaller) for the operation of supply vessels. The development needs to be watched and possibly encouraged to ensure a healthy competition in the market.

MONITORING OF THE CRUISES

The monitoring of the cruise programmes requires monitoring of two different aspects: the adherence of the operating agency or vessel to the schedules; and fulfilment of the assigned quantum of work for the cruise by the scientists. The deviation from the schedule (longer stays in port) are brought to the notice of the operating agency, the Shipping Corporation of India and remedial measures suggested. However, some delays in the port are related to factors beyond the operating agency's control; i.e. to the level of development of a port. The monitoring of the quantum of scientific work is carried out to identify areas of weakness, especially failures of instruments and machinery and measures adopted to improve the performance in future cruises.

The performance of the cruise is monitored by daily and monthly reports and annual reviews, which thus provides a system of checks and balances (Fig. 7).

BOATS AND SMALLER CRAFT

Boats can be used effectively and economically for surveys to a distance of up to 15 km from the coast with conventional position fixing. The range for surveys can be considerably increased with the use of electronic position-fixing systems. Because of the limited number of participants and restricted scope of operation, the programmes for boats are mainly finalized at the divisional/disciplinary level and are not reviewed by the national Cruise Planning and the Programme Priorities Committee. A wide variety of geological and geophysical surveys with position fixing by miniranger, echosounding, side-scan sonar, seismic profiling (sparker) and magnetometer have been carried out for a distance of about 15 km from the coast. The boats have been used for surveys for offshore placers, calcareous sands, oil and effluent pipeline routes and development of ports and harbours (Quantum of work, Table II, Typical configuration of equipment in Fig. 8). Smaller vessels (about 15 to 20 m LOA) are available for hire at many places along the coast. Hiring of a vessel for survey in an area has advantages, since the crew know the local navigational conditions and hazards. It has been the authors' experience that hiring of the boats for specific jobs along the coast has definite advantages compared to maintenance of a fleet of boats by the Institute.

UTILIZATION OF RESEARCH VESSELS AND COSTS OF SURVEYS

UTILIZATION OF RESEARCH VESSELS

The utilization of research vessels over the last decade (Fig. 9) was studied and the results indicate that the utilization of the vessels operated by the Institute (RV GAVESHANI of the CSIR and ORV SAGAR KANYA of the DOD) ranged from 42 to 78 per cent. The utilization of the chartered vessels for the project Surveys for Polymetallic Nodules ranged from 79 to 89 per cent which is considerably higher (Table III: Fig. 10). Based on this analysis the possibility of improving the utilization of RV GAVESHANI and ORV SAGAR KANYA was examined. The ORV SAGAR KANYA has been recently acquired and the vessel as usual required longer stays in the port for warranty repairs of deck machinery, scientific equipment and dry docking. It is expected that, with the completion of the warranty period, the utilization of the vessel would improve. A major refit of RV GAVESHANI is planned in the next few years, which will include the installation of a desalination plant and laundry on board, and these may also reduce the port stays. It is felt that the utilization of the vessels depends considerably on the planned endurance. RV GAVESHANI was planned for an endurance of 15 to 20 days and there will therefore be limitations in increasing the utilization by reducing the port stays. The port stay will not reduce proportionately for vessels with endurance of 6, 4 or 3 weeks.

The analysis of the utilization of the vessels for various scientific disciplines indicates that RV GAVESHANI has been utilized for a large part of the time for marine geosciences (Table III). It is related to the priorities at the Institute which are in turn related to the national priorities. Because of the national priorities, more funds were available for oil exploration and exploitation and to some extent mineral exploration, and therefore many of the surveys were entirely or partially funded by the oil industry or the Geological Survey of India.

The Council of Scientific and Industrial Research (CSIR) encourages collaboration in research programmes with other government departments, R & D institutions and the industries. These programmes are carried out as a part of an agreement between two organizations in which the expenditure on the programmes including shipboard work is shared. The analyses of the data indicate that most of the collaboration has been carried out in marine geosciences (Geological Survey of India, Oil and Natural Gas Commission and to some extent India Meteorological Department and Naval Research Laboratories). In the case of commercial surveys or research, the industry pays the charges according to a formula laid down by the CSIR. Such an arrangement develops a mutually beneficial relationship between the industry and research. It also provides an opportunity to the scientists to be associated with major projects of national development and application-oriented research. These also expose the scien-

tists to a new technology, which normally would not have been available within the resources of research institutes in a developing country and provide a very valuable financial input for the marine sciences programmes. The spin-off of these surveys has been the preparation of detailed surfacial geological maps of the western continental margin and magnetic-anomaly maps of offshore oil structures.

The analyses indicate that: (i) almost the entire sponsored surveys on research vessels were assigned to the Institute by the Oil and Natural Gas Commission; and (ii) most of the work has been carried out for problems in marine geosciences (surveys for development of offshore oil fields and pipeline routes).

COST OF SURVEYS

A system of costing of projects and surveys is useful to create an awareness in the scientists of the costs involved and the cost/benefit ratios. The CSIR therefore organizes short-term courses for the scientists in project planning and management. The cost of regional geological and geophysical surveys and precise surveys for offshore oil-field development on large vessels is expectedly considerably higher than the costs of exploration from small boats (Table IV). This is particularly important when planning for near-shore work and indicates undoubtedly that quite large areas of the continental shelf can be covered economically and perhaps more effectively with boats rather than large multidisciplinary oceanographic vessels. This should be considered by developing countries and is important not only in planning the programme but also for training the personnel.

CONCLUSIONS

The optimum utilization of the research vessels requires:

- (i) proper planning of the cruise, research and survey programmes and co-ordination with other organizations and the industry;
- (ii) availability of trained scientific and technical manpower for managing the cruise programmes, and servicing and repair of instruments;
- (iii) arrangements for the operation, servicing, and repair of research vessels.

The delegation of the operation of the vessel to a shipping company allows the scientists and Institute to devote more time to the scientific programmes rather than the management of the vessels.

The chartered vessels provide a better ship-time utilization for research institutes and the possibilities of utilizing these should be favourably examined for short-term and time-targeted programmes.

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Table I.-a

Research Vessels at Present in Operation in India

1	2	3	4	5	6	7	8
VESSEL	OWNER	YEAR OF BUILDING/ LAUNCHING	LENGTH (M)	BREADTH (M)	DRAUGHT (M)	CRUISING SPEED (KNOTS)	ENDURANCE (DAYS)
RV CONCH	UNIVERSITY OF KERALA	1956	15.25	-	1.40	11	-
FV BANGADA	MINISTRY OF FOOD AND AGRICULTURE	-	17.38	-	2.13	8	6
RV VARUNA	CENTRAL MARINE FISHERIES RESEARCH INSTITUTE	1961	30.6	7.4	3.9	10.0	30
SV ANVESHAK	OIL & NATURAL GAS COMMISSION	1973	-	-	-	-	-
RV GAVESHANI	NATIONAL INSTITUTE OF OCEANOGRAPHY	1975	68.33	12.19	3.0	10	25

Table I-a
(continued)

VESSEL	DISPLACEMENT TONNAGE	BEAM	ACCOMMODATION			SCIENTIFIC CAPABILITIES
			CREW	SCIENTISTS		
	9	10	11	12	13	
RV CONCH	40	4.5	6	7		N: Electric ship's log C: Radio telephone S: Echosounder, hydrographic winches
FV BANGADA	50	5.12	9 (TOTAL)			N: Magnetic compass, Ship's log, radio direction finder: C: Radio telephone S: Echosounder, roller-type trawl winch
RV VARUNA	160	-	13	5		N: Magnetic compass, electric ship's log, Decca radar, direction finder S: Echosounder C: Radio telephone; Two hydraulic winches, Three laboratories
SV ANVESHAK			24	16		N: Integrated navigation system C: Radio telephone S: Multichannel seismic equipment
RV GAVESHANI	1900	-	45	19		N: Omega, Decca Navigator, Mini Ranger gyrocompass, radars, Tracor Magnavox, satellite position fixing system; C: Radio telephone, VHF S: 12 KHz narrow-beam precision depth recorder, narrow-beam echo-sounder ± 1.4 degree gyro stabiliser, 3.5 KHz sub-bottom profiler sparker, magnetometer, bathysonde, deep sea grabs, free- fall grabs, free-fall corer, dredges, coring winch, traction winch, bathysonde winch

Table I-b

1	2	3	4	5	6	7	8
ORV SAGAR KANYA	DEPARTMENT OF OCEAN DEVELOPMENT	1983	100.34	16.39	5.6	14.25	45

S. S. Sanyal
Sarabjit Mandal

Table I-b
(continued)

VESSEL	9	10	11	12	13
ORV SAGAR KANYA 4209	-	59	32		
					<p>N: Integrated satellite navigation system, visual radio direction finder, Decca navigator with track plotter, automatic VHF radio direction receiver, radar navigational echosounder for graphic display, electromagnetic speed log, gyro compass and electronic automatic pilot.</p> <p>C: SSB radio, Marconi radio telex, radio station, satellite radio unit, VHF.</p> <p>S: 3-frequency narrow-beam sounder, deep-sea sediment echosounder, shallow-water echosounder, TV with tripod sub-sea camera equipment, photo camera sledge, free-fall grabs with camera, underway sampler, radiograph for cores, proton magnetometer, marine gravitometer, 24-channel digital seismic equipment, side-scan sonar with sea-floor mapping system, expendable bathythermograph, hydrocarbon water sampler, shipborne wave-recorder system, mooring system, thermosalinograph, CTD-02 profiling system, spectrofluorometer, UV-spectrophotometer, atomic absorption spectrometer, fluorometer, high-speed plankton net, standard pressure meter, midwater trawling net, combined wind weather radar, pyranometer, pyrheliometer, meteorological data logging system, radio-sonde, general-purpose computer system, and multipurpose data-logging system, etc.</p>

Table I-c

1	2	3	4	5	6	7	8
RV SAMUDRA-MANTHAN	GEOLOGICAL SURVEY OF INDIA	1983	88.83	12.95	5.05	12.4	25
MV POLAR CIRCLE*	A/S G.C REIHER BERGEN, NORWAY	1972	42.35	11.5	4.79 (Summer middle) 4.10 (Ice breaker)	13	-
MV SKANDI SURVEYOR**	P/R OCKLAND AND CO., NORWAY	1974	73.26	11.58	-	14	-
MV FARNELLA*	M/S J.MARR AND SONS LTD. U.K.	1976	76.6	-	-	11	-

* Chartered vessels now demobilized.

Table I -c
(continued)

VESSEL	9	10	11	12	13
RV SAMUDRA- MANTHAN	1272.5	-	36	25	<p>N: Integrated satellite navigation system, Doppler sonar, gyrocompass, direction finder, radar</p> <p>C: VHF, main and emergency transmitter, main and emergency receiver</p> <p>S: Dual-frequency echosounder, dual-channel side-scan sonar, marine proton magnetometer, hydrosonde system, finger, vibrocorer, free-fall grab, spade corer.</p>
MV POLAR CIRCLE	495.71 Rt		34 (total)		<p>N: Satellite navigation</p> <p>C: Satellite communication</p> <p>S: Echosounder, magnetometer, side-scan sonar, sparker</p>
MV SKANDI SURVEYOR	1200		44 (total)		<p>N: Dual-channel satellite navigation system</p> <p>C: Radio transmitter</p> <p>S: Echosounder, magnetometer, facsimile weather recorder, free-fall grabs with camera, ocean mining dredges, X-ray, fluorescence analyser</p>
MV FARNELLA		12.65			<p>N: Satellite and Omega navigator</p> <p>C: Radio transmitter, satellite communication</p> <p>S: Magnetometer, echosounder, weather recorder, free-fall grab with camera, ocean mining dredges, boomerang corer, box corer, atomic absorption spectrometer</p>

Table II : Surveys by Small Craft - Quantum of Work

Surveys	Echosounding (ℓ km)	SSS* (ℓ km)	Seismic (ℓ km)	Magnetic (ℓ km)	Samples	Approx. area sq. km.	Scale
1. Offshore placers	2088	54	897	1136	1640	94	1:10,000
2. Calcareous sands	1123	-	-	-	2605	385	1:5,000 & 1:10,000
3. Oil pipelines	860	915	918	-	55	252	1:10,000 & 1:25,000
4. Effluent pipelines	427	347	407	-	73	85	1:10,000 & 1:15,000

* Side-Scan Sonar

Table III: Research Vessels: Utilization, R & D Disciplines and Sponsored Surveys

Year	Disciplines (Days)							Multi- Disciplinary
	Physical Oceanography	Chemical Oceanography	Biological Oceanography	Marine Geosciences	Ocean Engineering			
<u>RV GAVESHANI</u>								
1976	29	48	12	59	-	-	7	
1977	1	-	-	133	-	-	49	
1978	4	-	-	127	-	-	81	
1979	59	-	-	60	-	-	35	
1980	3	-	-	120	-	-	113	
1981	-	-	-	29	11	-	157	
1982	19	-	-	121	6	-	55	
1983	-	13	-	12	-	-	196	
1984*	-	-	13	45	-	-	21	
<u>ORV SAGAR KANYA</u>								
1983	-	-	-	33	-	-	184	
1984*	-	-	-	63	-	-	-	
<u>MV SKANDI SURVEYOR</u>								
1982	-	-	-	132	-	-	-	
1983	-	-	-	259	-	-	-	
<u>MV FARNELIA</u>								
1982	-	-	-	19	-	-	-	
1983	-	-	-	309	-	-	-	
1984	-	-	-	25	-	-	-	

* up to April 1984

Table III
(continued)

Year	Surveys (Days)		Port Calls and Repairs (Days)			Remarks	
	R & D Surveys	Sponsored Surveys Chiefly O.I. Field Development	Total for Surveys	Port Calls and Dry Dock- ing	Annual Repairs Total Port Calls and Repairs		Utilization Per Cent
<u>RV GAVESHANI</u>							
1976	92	63	155	40	132	172	47.4
1977	115	68	183	114	68	182	50.1
1978	138	74	212	99	54	153	58.1
1979	125	29	154	146	65	211	42.2
1980	187	49	236	53	76	129	64.5
1981	197	-	197	112	56	168	53.9
1982	201	-	201	78	85	163	55.1
1983	221	-	221	83	61	144	60.5
1984*	79	-	79	42	-	42	65.3
<u>ORV SAGAR KANYA</u>							
1983	217	-	217	61	-	61	78.1
1984*	63	-	63	22	36	58	52.1
<u>MV SKANDI SURVEYOR</u>							
1982	132	-	132	23	-	23	80.7
1983	259	-	259	43	-	43	85.8
<u>MV FARNELLA</u>							
1982	19	-	19	5	-	5	79.2
1983	309	-	309	56	-	56	84.7
1984	25	-	25	3	-	3	89.3

The ship was chartered from 30.7.82 to 29.10.1983

The ship was chartered from 7.12.82 to 22.1.1984

* up to April 1984

Table IV: Cost of Various Surveys

Surveys	Cost (in Rs.)		
	per line Km.	per sq. Km.	per sample
1. Regional Geological and Geophysical (20-km. grid)	150 - 500	20 - 135	1,000-1,700
2. Precise for oil-field development			
i) Platform (4 x 2 km grid)	-	1,500 - 5,200	-
ii) Pipeline	325 - 1,100	-	-
3. On small craft			
i) Offshore placers	100 - 250	1,700	125 - 150
ii) Oil pipelines	550 - 750	-	-
iii) Effluent pipelines	200 - 400	2,000	-

Figure 1

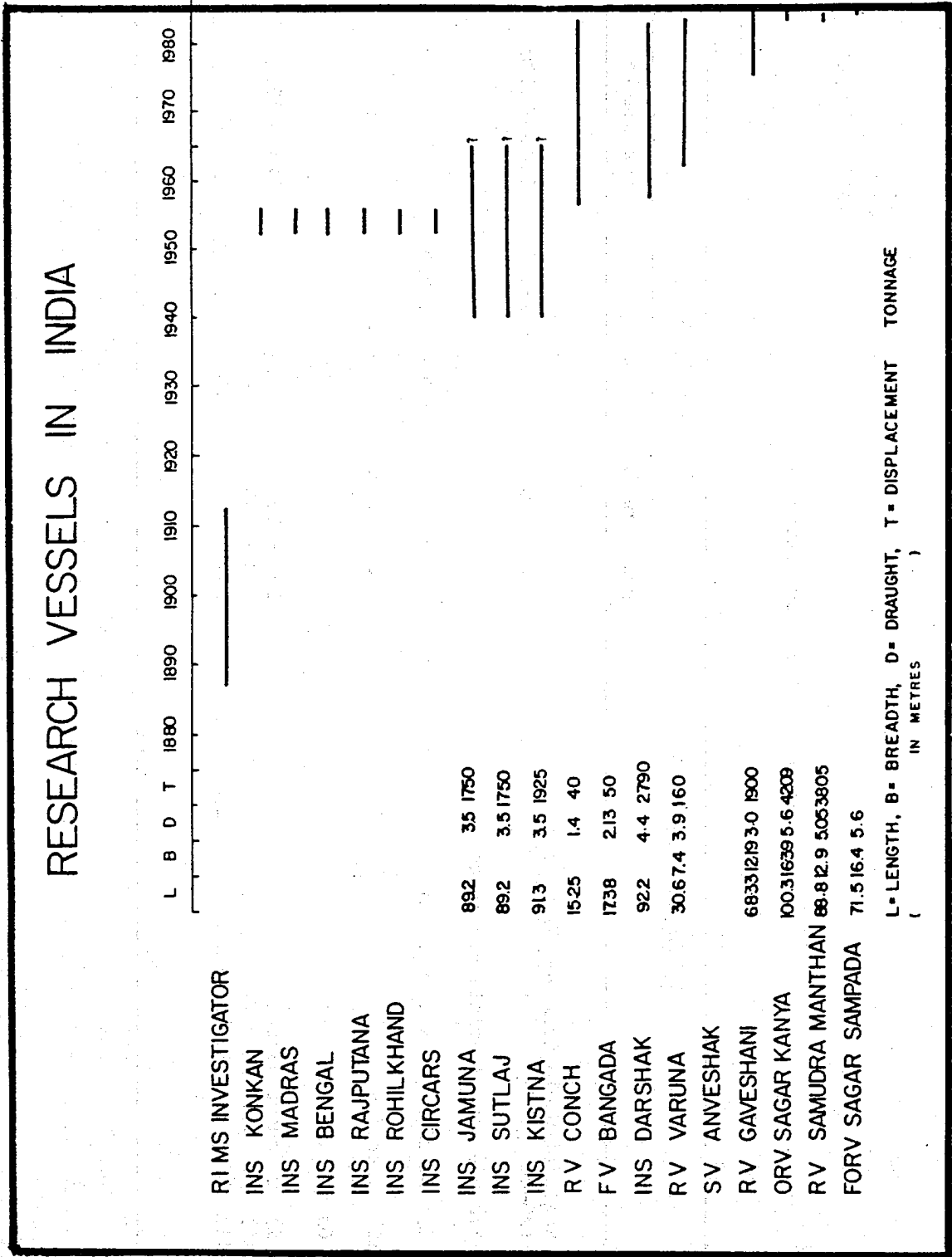


Figure 2
Planning and decision-making for cruises,
financial support and operation and maintenance of research vessels

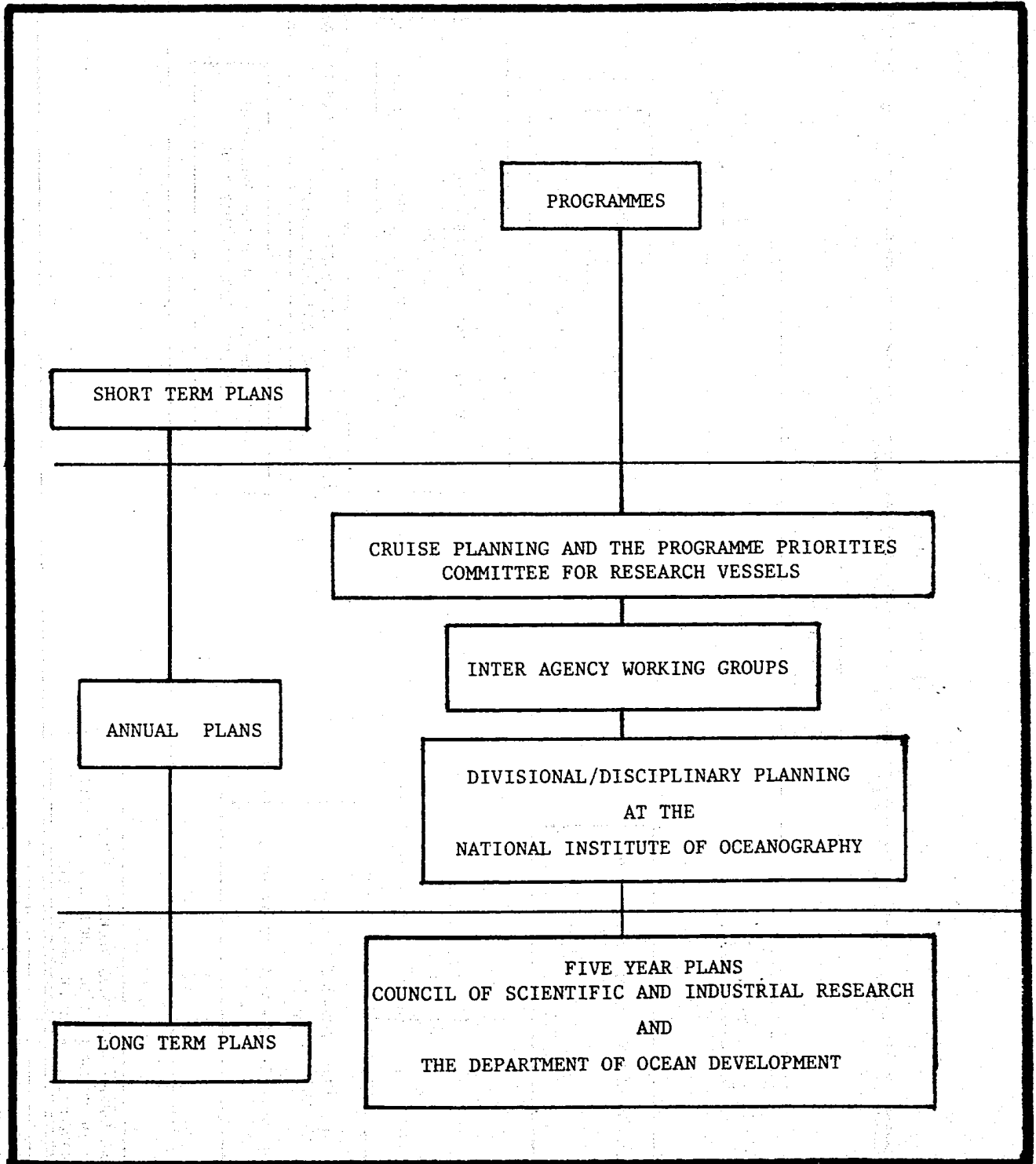


Figure 2 cont.

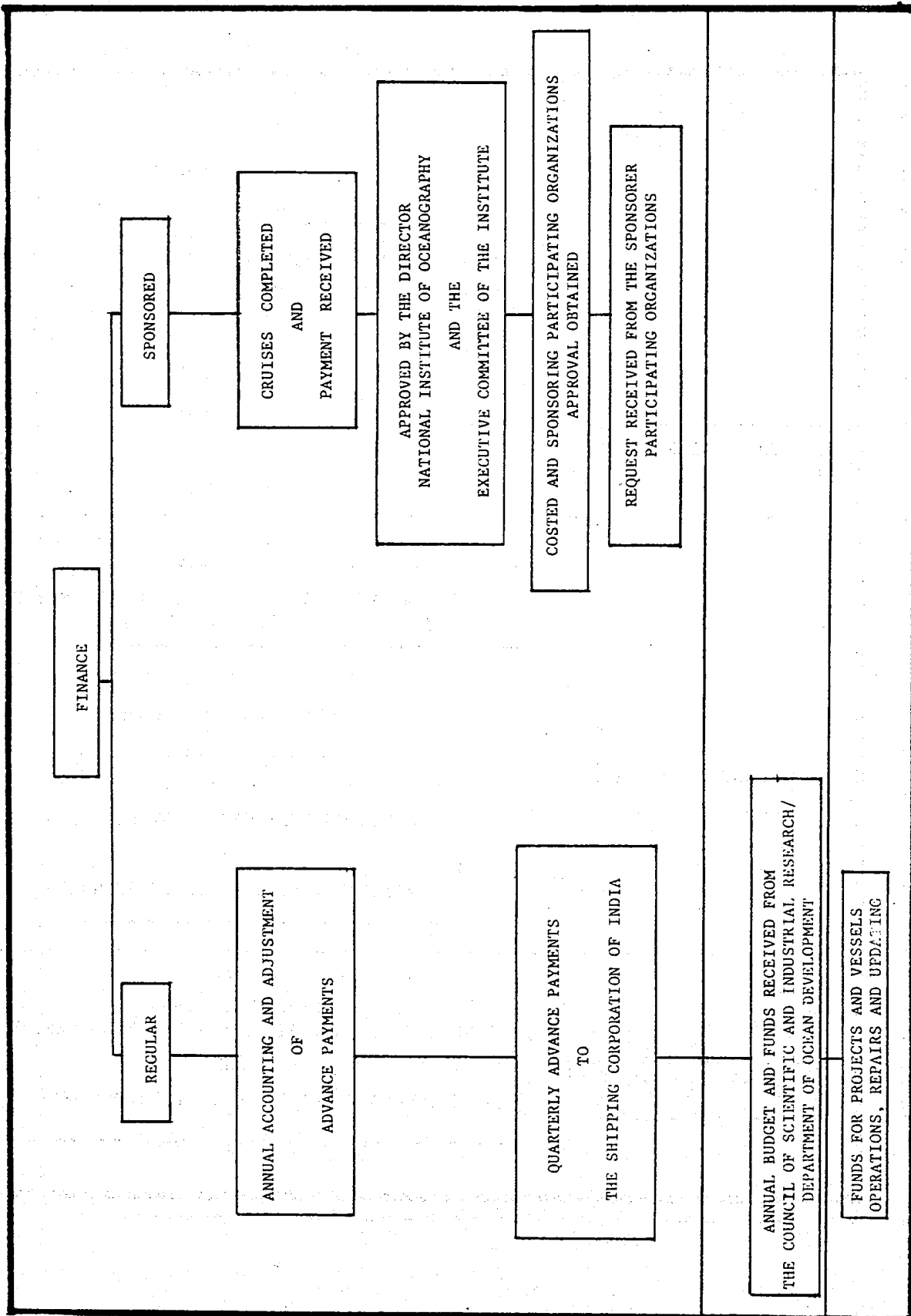


Figure 2 cont.

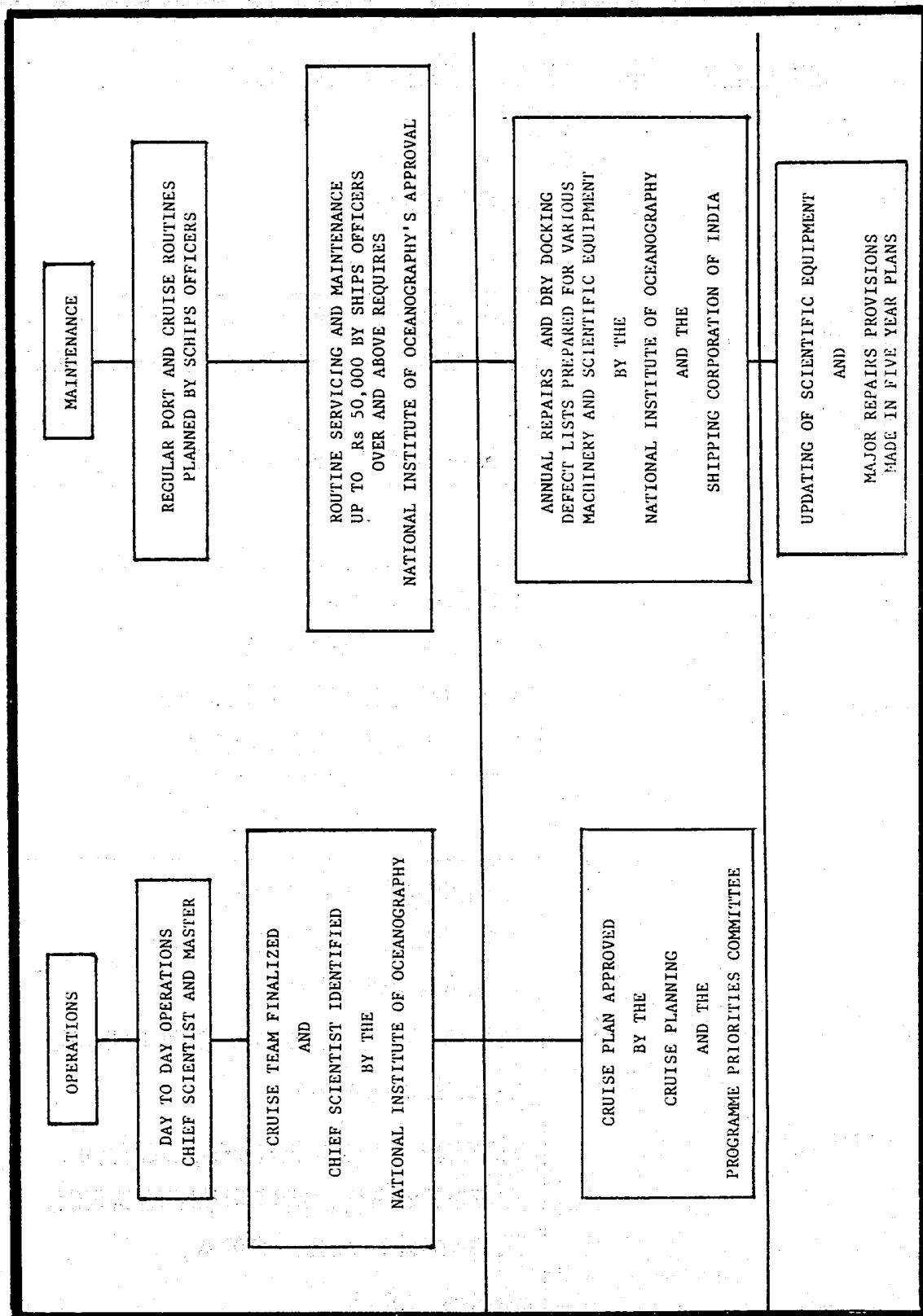


Figure 3

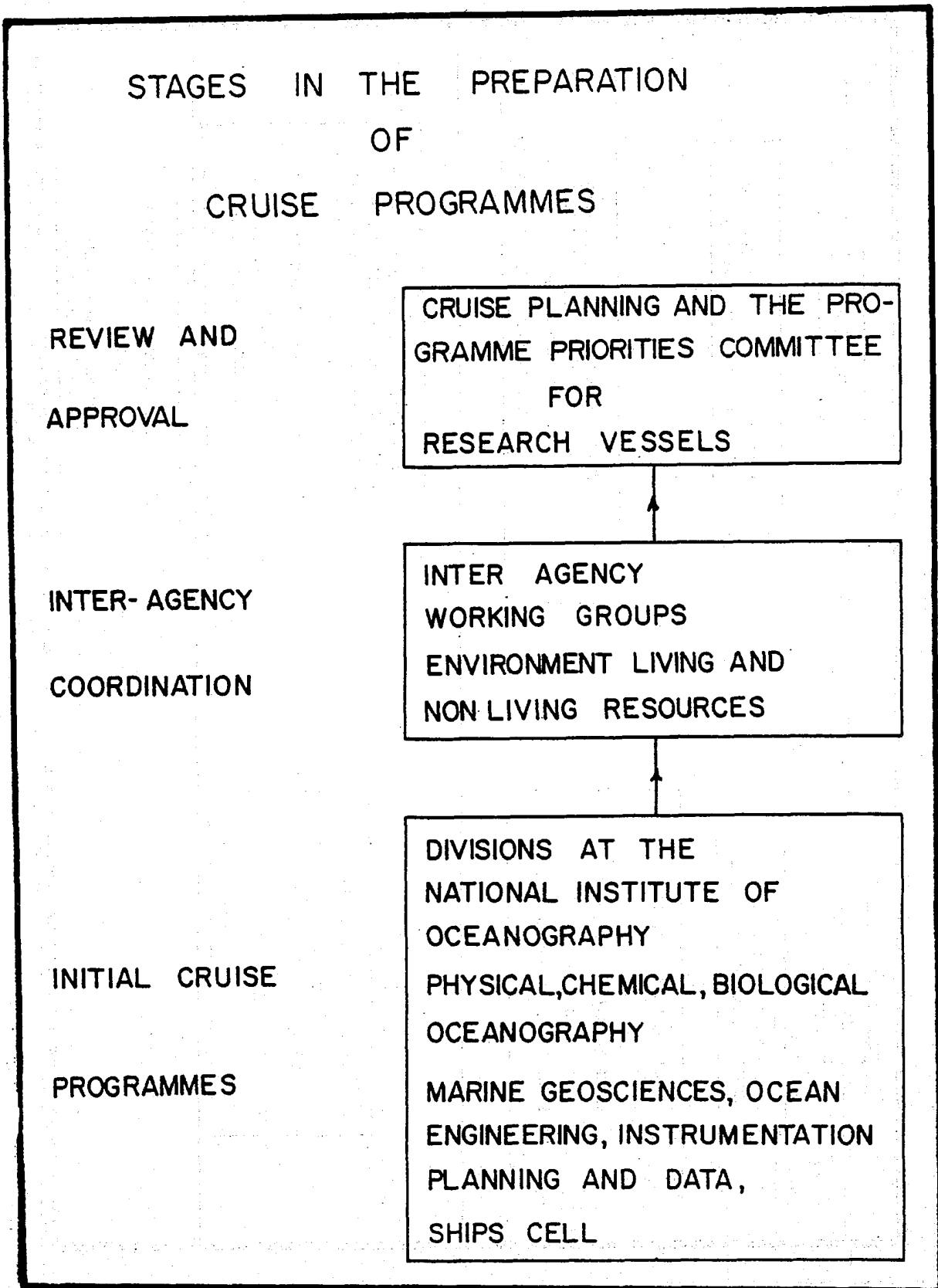


Figure 4

CRUISE PLANNING AND THE PROGRAMME PRIORITIES COMMITTEE

FOR

RESEARCH VESSELS

(R V GAVESHANI AND O R V SAGAR KANYA)

CHAIRMAN

Secretary Department of Ocean Development

(Government of India)

PLANNING COORDINATION MANAGEMENT
AND EXECUTION OF SCIENTIFIC PROGRAMMES

National Institute of Oceanography
Council of Scientific and Industrial Research
Department of Ocean Development

OPERATION OF RESEARCH VESSELS

Shipping Corporation of India

LIVING RESOURCES

National Institute of Oceanography
Central Marine Fisheries Research Institute
Indian Council of Agricultural Research

NON-LIVING RESOURCES

National Institute of Oceanography
Geological Survey of India
Oil and Natural Gas Commission
National Geophysical Research Institute

ENVIRONMENT

National Institute of Oceanography
India Meteorology Department
Central Board for Water Pollution and Control

OTHER INTERESTED AGENCIES

Ministry of External Affairs
Ministry of Communication
Ministry of Shipping and Transport
Department of Science and Technology
Naval Hydrographic Office
Naval Physical and Oceanographic Laboratory
University Grants Commission
Coast Guard
Central Electrical Authority
Centre for Earth Science Studies

Figure 5

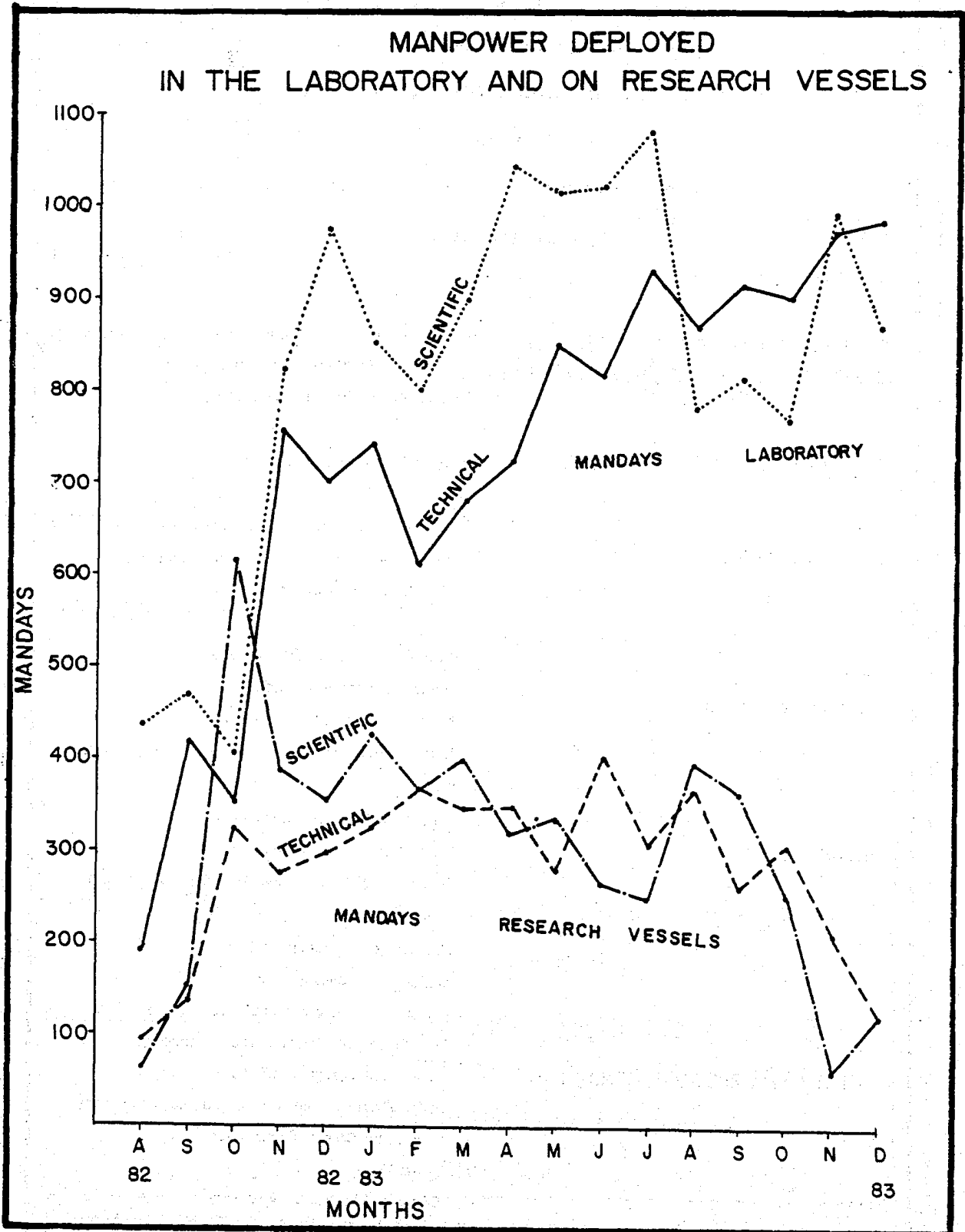


Figure 6

DEPLOYMENT OF MANPOWER IN PROJECT AND ON RESEARCH VESSELS

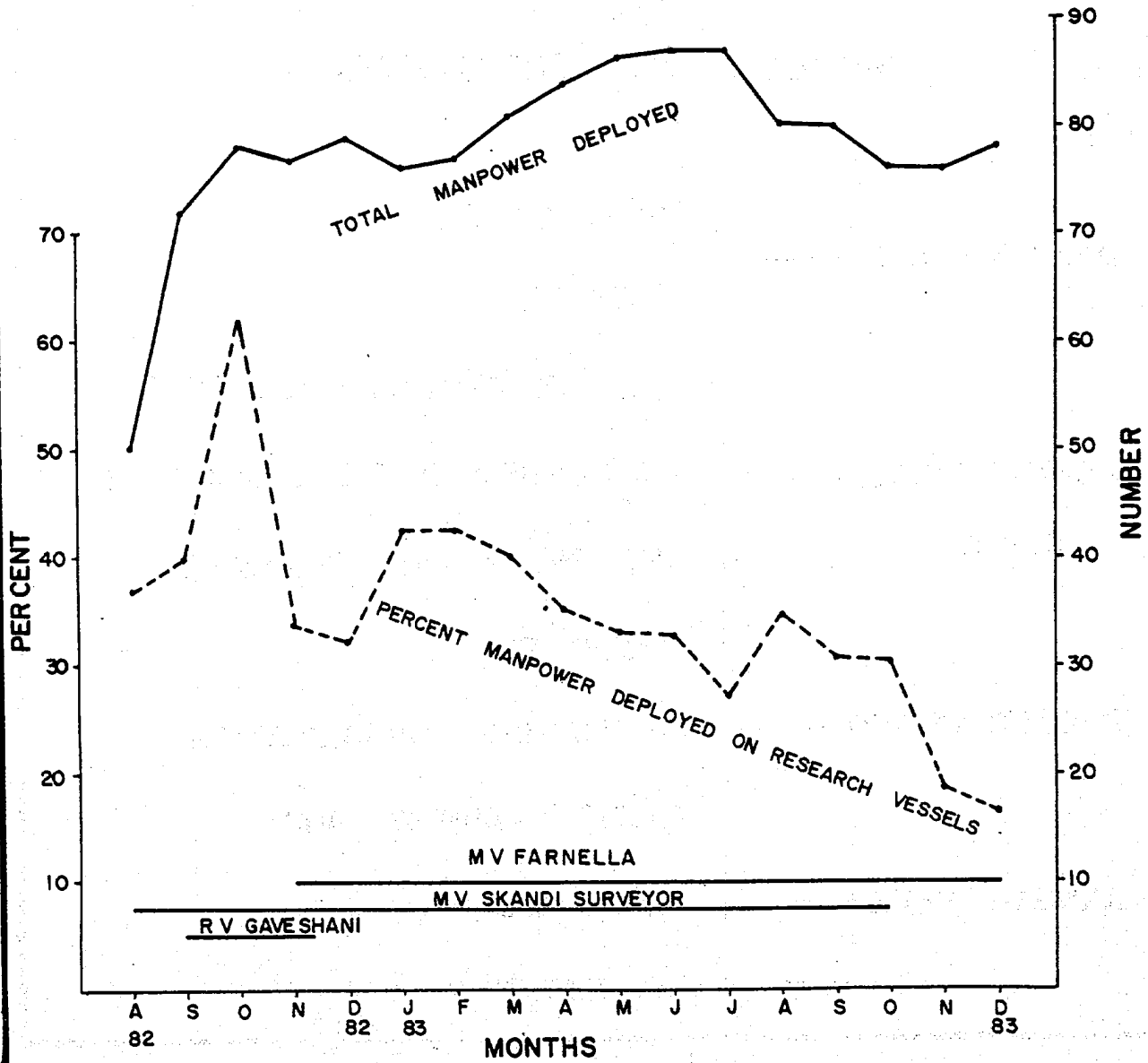


Figure 7

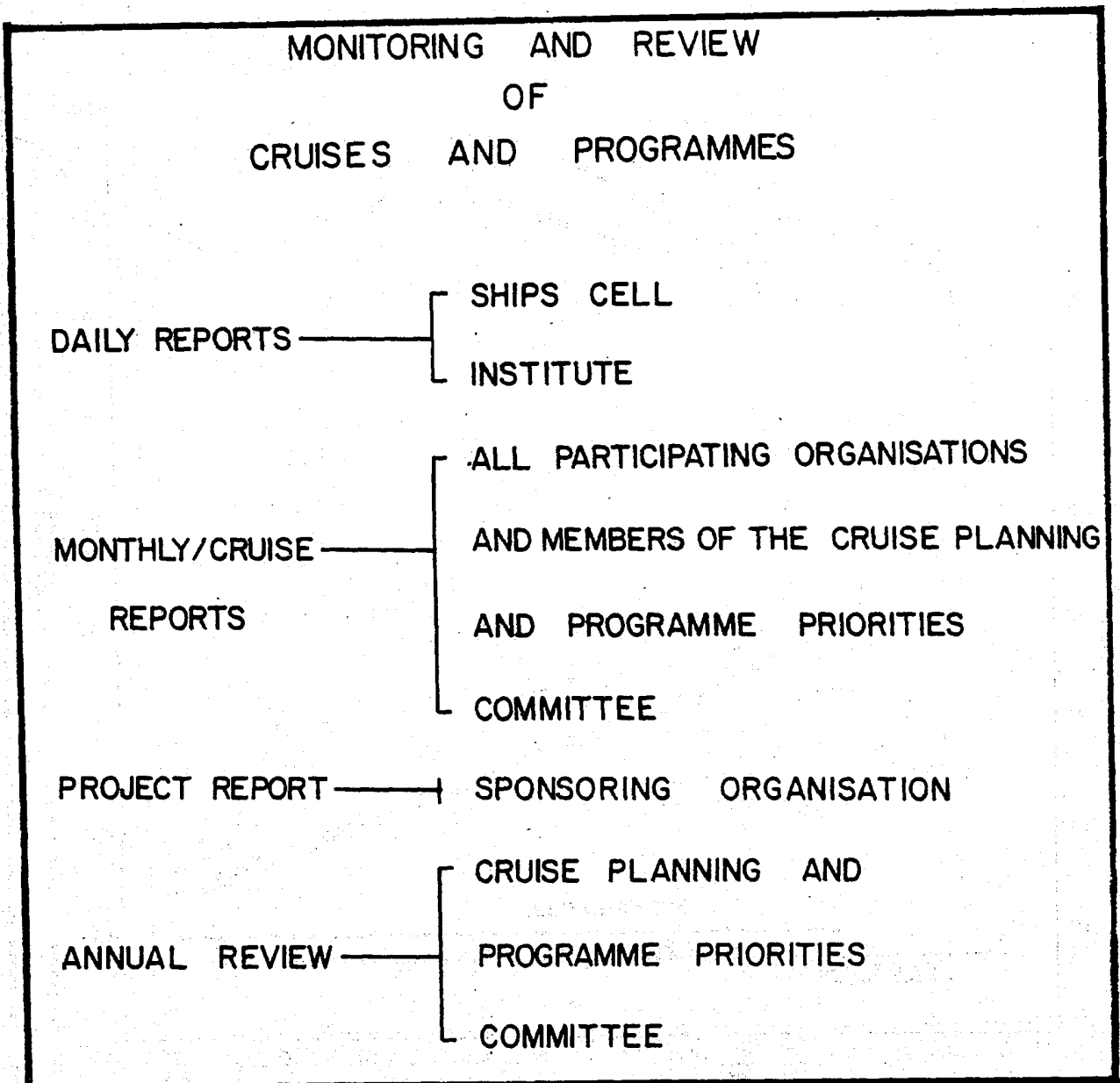


Figure 8

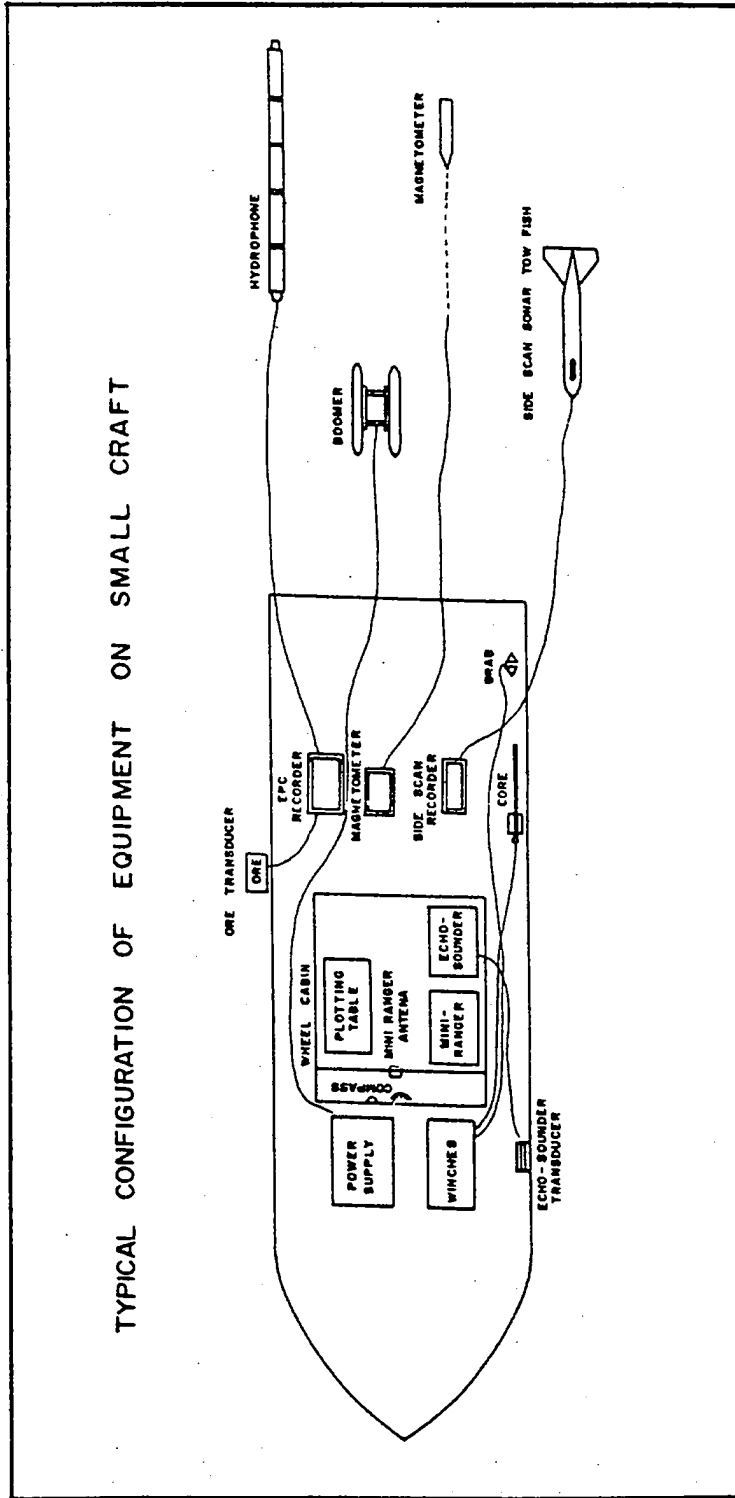


Figure 9

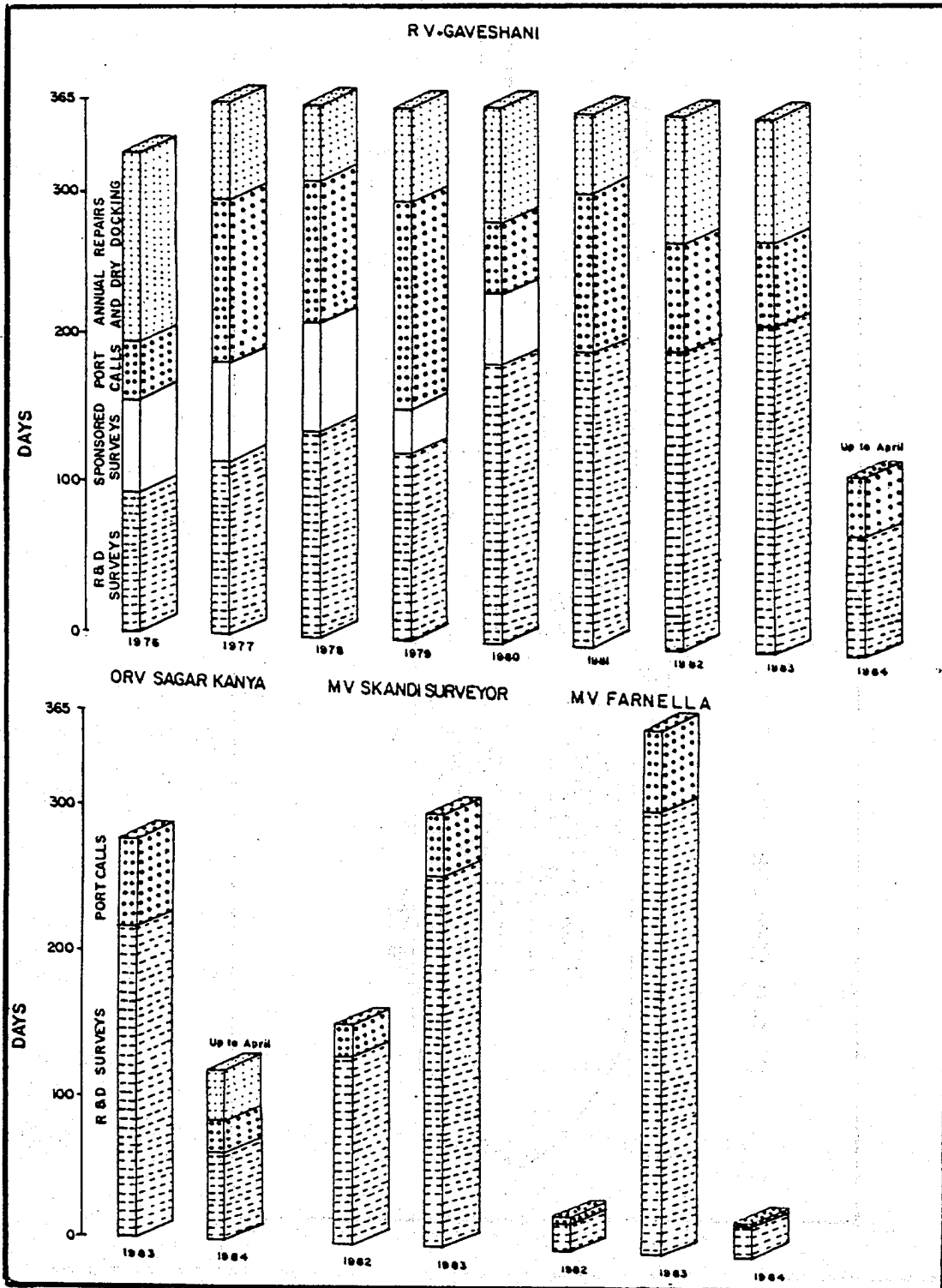


Figure 10

