Snellius II as a policy instrument for marine capacity building

J.H. Stel

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Jan H. Stel, Earth and Life Science Foundation, Laan van N.O. Indië 131, 2593 BM The Hague, and International Centre for Integrative Studies (ICIS), University of Maastricht, P.O. Box 616, 6200 MD Maastricht - The Netherlands.

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Indonesia is the largest archipelago in the world (1.8 million km^2 of land, 3.1 million km^2 of sea, plus a 200 miles Exclusive Economic Zone covering some 2.7 million km^2). Its population, ranking number four on the world list, amounts to more than 216 million people. Marine related programmes are given a high priority in Indonesia. During the last two decades the government has carried out a concerted effort in marine capacity building through bilateral, regional and international co-operation. This effort included increasing man-power development, expanding and improving research facilities, establishing a national marine data centre, improving co-operation within the Indonesian marine science community, and international co-operation. The bilateral agreement with The Netherlands for the implementation of the Snellius II Programme (1982-1987) laid the intellectual basis for the Indonesian marine science capability. The necessary research vessels were obtained through bilateral co-operation with France and Norway. At present Indonesia operates: (1) a network of tide gauges and current meter stations, (2) two satellite ground stations, (3) tropical radar wind profiling stations, (4) a network of marine pollution stations, (5) eight ocean-going, coastal and fisheries research vessels, and (6) twelve Seawatch monitoring buoys. The present commitment to maritime affairs is reflected in the establishment of a new Ministry for Maritime Exploration and Fisheries in which are brought together at a policy making and co-ordinating level, most aspects of sustainable use of Indonesia's ocean space. It is expected that, in the near future, Indonesia will play a major role in marine affairs in the western Pacific region. This paper provides a review of Indonesian experience in developing a national marine capability and the catalysing role of the Snellius II Programme in this.

Introduction

Indonesia is the largest Archipelago in the world. The 3.1 million km^2 seas cover about two thirds of its territory. The 200 miles Exclusive Economic Zone adds another 2.7 million km^2. By contrast the land area of Indonesia is 1.8 million km^2 (fig. 1). With a population of more than 216 million people (July 1999), Indonesia ranks number four at the world list behind China, India and the USA. Marine related programmes are given a high priority by the Indonesian government. During the last two decades the Indonesian government has carried out a concerted effort in marine capacity building through bilateral, regional and international co-operation. The Indonesian Archipelago is situated between the Asian and the Australian continents and between the Pacific and Indian Oceans. The archipelago consists of some 17,000 plus islands and islets with more than 81,000 km of coastline, and waters covering two-thirds of its territory. Sustainable use of this resource will not only affect the Indonesian economy in the coming decades, but also its ability to meet the increasing demand for food and raw materials, its position and influence in the region, its national resilience, and the environmental quality of the country as a whole. For centuries the rich and diver-

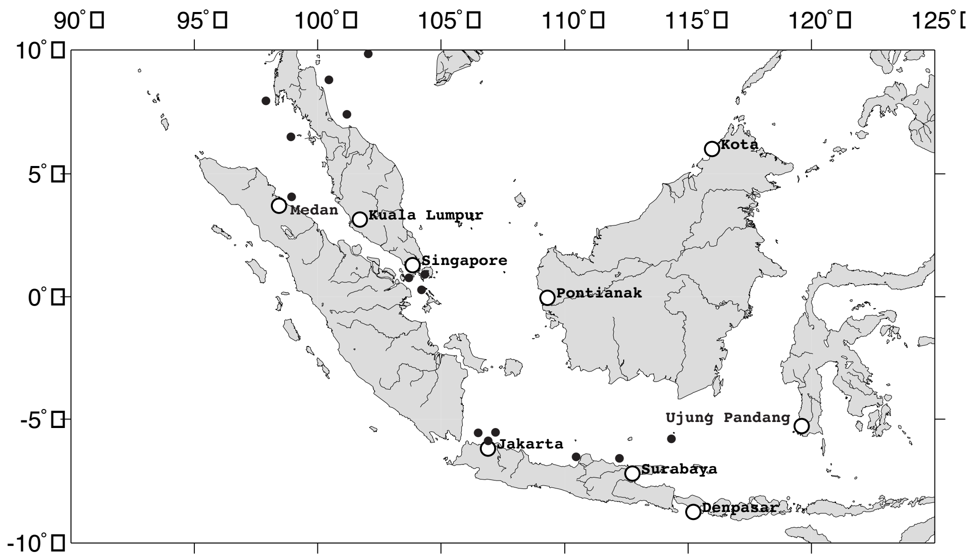

Fig. 1. Indonesia, the 'maritime continent' covers 1.8 million km^2 of land and 5.8 million km^2 of ocean space. Its population of over 216 million ranks number four in the world.

sified life of the Indonesian seas has been an important source of food yielding fish, crustaceans, molluscs, and seaweed. In addition minerals and oil and gas are currently exploited from the continental shelves in the Java Sea and Makassar Strait. Aside from these renewable and non-renewable resources, the sea has many other functions, such as for inter-island traffic, regional and international shipping, communication, recreation and tourism. To enhance and increase the economic return from the marine sector, Indonesia has consistently developed a national capability in these fields. Manpower and infrastructure development took place through bilateral, regional and international co-operation.

Indonesian oceanographic features

Nearly all types of topographical features are found in the Indonesian seas, such as shallow continental shelves, deep sea basins, troughs, trenches, continental slopes, and volcanic and coral islands. The distribution of water and land alone makes the Indonesian Archipelago one of the most complex geographic structures on earth. Numerous large and small islands divide the waters into different seas connected by channels, passages, and straits. Due to this unique geographic setting, Indonesia can be seen as a 'maritime continent'. The complexity of the region is the reason why it has attracted many major international oceanographic expeditions, such as the Challenger (1872-1875), the Gazelle (1885), the Valdivia (1899), the Siboga (1989-1900), the Planet (1906-1907), the Snellius (1929-30); the Albatross (1948), the Spencer F. Baird (1947-50), and the Galathea (1951). In recent years, some oceanographic cruises have also been organised locally or as part of co-operative regional studies. Examples of the latter are the Co-operative Study of the Kuroshio, which also covered the South China Sea, of the Intergovernmental Oceanographic Commission (IOC), the International Indian Ocean Expedition (IIOE), and the bilateral Indonesian-Dutch Snellius II expedition (1984-1985).

The Indonesian Archipelago is strongly governed by the monsoonal climate. The Northwest monsoon lasts from December to February/March and the Southeast monsoon from June to August. The rests of the year represents the transition periods from the Northwest to the Southeast monsoon (March to May) and from the Southeast to the Northwest monsoon (September to November). The monsoons strongly affect the oceanographic features of the Indonesian region (Soegiarto, 1985; Soegiarto & Birowo, 1975). As a consequence the Indonesian waters are ideal for studying the effects of the monsoons on both water circulation and seasonal distribution of its physical, chemical, and biological properties. Within the Climate Variability Programme (CLIVAR) monitoring of the Indonesian throughflow together with the installation of Seawatch moorings in the Bay of Bengal, the Arabian Sea and along the equator in the northern Indian Ocean as well as the deployment of Japanese Triton buoys as part of the El Niño monitoring system west of Sumatra, have a high priority for a better understanding of the role of the Indonesian waters in the regional and global climate (Lau et al., 2000).

The Indonesian seas form a unique tropical inter-ocean link, connecting the reservoir of the warm surface water mass of the western Pacific with the eastern Indian Ocean, while transforming it through vertical mixing and air-sea interaction on its way. The heat and water mass flux between both oceans is estimated to be considerable and has a large, perhaps even global scale impact on the oceanic climate. Indonesia geographically is in the centre of some of the most pressing issues in climate research, such as the understanding of the variability of El Niño, the interaction between the Pacific and the Indian Oceans, the prediction of the monsoon, and the 'Conveyer belt' model (fig. 2) of the global oceanic circulation.

Uncontrolled fires raging havoc throughout Indonesia during the fall of 1997, increased both international awareness and political pressure to deal with the social and economic effects of El Niño. Most of these fires were set by big landowners, commercial loggers, and small farmers, in attempts to clear and cultivate the land, as people have done in the past. However, as was predicted, the El Niño induced drought postponed the rainfall that could have extinguished the flames and washed away the smoke and haze in the region. Similar situations took place during the El Niño years of 1987, 1991, and especially between 1982-1983, when another major El Niño occurred with an estimated global economic loss of some US$ 13 billion. The economic loss of the 1997-98 El Niño for Indonesia is an estimated US$ 6 billion. The region-

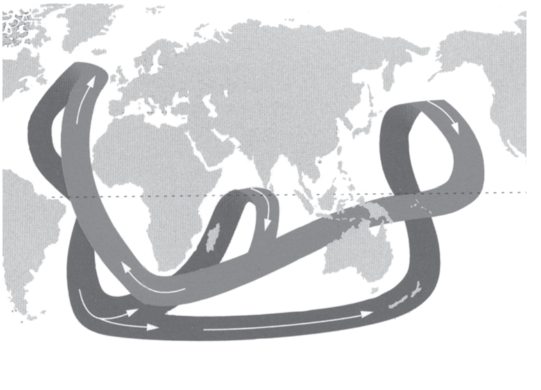

Fig. 2. In the 'Ocean Conveyer Belt' model of ocean circulation, surface currents and deepwater currents are integrated in one global current system.

al impacts of the fires was severe, but the long-term, global atmospheric consequences are limited. They can be compared with the fires in the Brazilian Amazon and the African savannah. Yet if an adequate response system had been in place, the Indonesian government could have minimised the effect of this El Niño and, as a consequence, would the loss of man and nature have been dramatically less. The government of Peru for instance was one of the first governments to learn its lessons from the 1982-83 El Niño, leading to the destruction of that years crop, by using El Niño forecasts to advice the Peruvian farmers either to grow rice or cotton during respectively a normal or an El Niño year. Similarly, wheat farmers in northern Australia can increase their profits by up to 20% and /or reduce the risk of an annual loss up to 35%, if seasonal rainfall predictions based upon El Niño forecasts are used to guide crop management. In the same way the Indonesian government should use El Niño forecasts in managing its resources at a regional level.

Development priorities in the marine sector

In 1993 Indonesia completed her First 25 Year Long Term Development Plan (1969-1993), which was divided into 'Five Year Development Plans'. Agriculture, small and basic industries were the priorities of this development plan. The second 25 Year Long Term Development Plan (1994-2020) has been formulated and approved by the Supreme People Council in March, 1993. The marine sector in Indonesia has been identified as one of the most important sectors for achieving the goals as defined in this plan and in the sixth five year plan (REPELITA VI). As a consequence the development of maritime industries such as fisheries and aquaculture, oil and gas industries, ship-building, sea communication and port development, tourism, defence security, and mineral resources, is a priority (Soegiarto, 1997).

Fisheries and aquaculture

The Indonesian marine environment offers a vast potential for the development of fishing activities. Similarly the more than 81,000 km of coastlines offer unique opportunities for aquaculture and marine farming activities. The total output of fisheries and aquaculture was 3.3 million metric tons in 1991, with an export value of US$ 1,807 million. In 1995 the total production had reached 4.2 million tons with an export value of US$ 1,808 million and the fishery production consisted of about 77% marine and 23% freshwater fishes. The exports are dominated by prawns and tuna (Murdjijo, 1996). In addition, the fisheries and aquaculture industries contribute significantly to the urgently needed protein sources of the country. The average consumption in 1996 was 19.39 kg of fish/capita/year. Many coastal communities are totally dependent on the food from the sea. The sustained potential of marine fish production per year is an estimated 4.5 million tons from the archipelagic waters and 2.1 million tons from the Exclusive Economic Zone (EEZ). The aquaculture and marine farming activities potentially can produce as much as 2.5 million tons per year. A yield of 4.8 million tons in 1997, means that Indonesia just produced slightly more than half of the total fishing- and acquaculture potential. Some constraints in the fishery production are:

— The majority of harbours do not have cold storage and production facilities.
— Fish farming and production systems are not yet fully developed.

— The fish production industry depends on marine fisheries, while fish farming and/or aquaculture products are still not fully developed.
— A limited data and information system for supporting marine fishery and fish farming.
— Less developed post harvest processing of sea-food products.
— A weak marketing and distribution network.

Just recently the Indonesian government announced that some 50 million US$ is needed to stimulate the production, quality and export of the fishery sector. Through this investment the Indonesian government aims at bringing the export value from its present level of some 2 billion US$ to 10 billion US$ in 2005.

Oil and gas

In the 1970s, oil has financed and fuelled the Indonesian economic development by contributing more than 80% to the national revenues. With the growth of the non-oil sectors, the oil industry now contributes a substantial, but much lower, 25% to the national revenues. Oil and gas continue to be Indonesia's most important export products. In 1997 the export value of crude oil was US$ 5480,9 million and for Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG)respectively US$ 4709,7 million and US$ 493,7 million. Almost 35% of the oil production is derived from offshore fields, in particular from the Java Sea and Makassar Strait. Another large percentage comes from coastal areas. LNG and LPG play an increasingly important role. The Indonesian share of the international market for LNG and LPG has grown rather spectacularly. By 1987 Indonesia ranked as the world's leader of LNG and LPG export, holding over 40% of the global market.

Oil and gas resources from offshore areas are mostly located along the eastern coast of Sumatra, in the east of Kalimantan and within the western zone of Irian Jaya. At present they are not yet fully exploited. Aceh, N Sumatra, Bontang, the eastern coast of Kalimantan, Natuna Islands (in the Chinese Sea) and Irian Jaya have Indonesia's most abundant gas resources. Data show that Indonesia has 60 Tertiary sedimentary basins, which are rich in oil and natural gas. Seventy three percent of these basins are located offshore. Out of the 60 basins, 14 are already producing, seven have been drilled and proven oil productive, 15 are in an explorative drilling phase and 24 are still untouched due to their location in deep water (Soegiarto, 1997). The estimated reserve is 73.3 billion barrels of oil and 307.95 trillion cubic feet of gas.

Indonesia has eight oil refinery plants with a total processing capacity of 99.1 million barrels per day. These plants are located in Pangkalan Brandan, Dumai, Sungai, Pakning, Musi, Cilacap, Cepu, Balikpapan, and Balongan.

The activities of the oil and gas industry in Indonesia include extensive offshore exploration and production, heavily used inter-island tanker routes, and international routes serving the Pacific Rim nations and refineries and large scale terminal operations. Each of these activities might lead to oil spills. In addition, the development of onshore petroleum facilities, such as oil terminals and refinery facilities, could effect the local ecosystems through chronic discharge of pollutants, etc. (Soegiarto & Kinarti, 1990). This may lead to a loss of income from other marine sectors such as aquaculture and tourism.

Shipping and ports

Indonesia as an archipelagic nation, relies on shipping as an important mode of transportation of natural resources, goods and people. Therefore, it is essential to develop shipping and port systems to facilitate the use of Indonesia's natural resources, to promote economic development, to reduce costs of trade and to increase oil and gas as well as non-oil exports. In 1992 there were registered 344 inter-island vessels with a capacity of 843,000 DWT (Dead Weight Ton), 1,119 local transportation vessels (180,000 DWT), 3,974 vessels for transporting people (209,000 DWT), and 27 international vessels (347,000 DWT) in the Indonesian waters. In 1999 the Indonesian merchant fleet consisted of 587 ships with a capacity of over 1,350 DWT, adding up to a total capacity of 3,701,001 DWT. Currently, Indonesia has 2,384 ports of which 113 are open for international trade (pers. comm. Department of Communication). Major ports are: Cilacap, Cirebon, Jakarta, Kupang, Palembang, Semarang and Ujungpandang. The development and maintenance of ports, ship building, transportation technology and management is very important as traffic of container ships in the Asian and Pacific region has increased substantially. Some constraints in sea transportation are:

— Business character which is reflected in slow growth because of the need of huge investments to boost the business.
— International competition which is disturbed by protection and subsidies from governments.
— Financial institutes which are reluctant to support investments due to the high risk.
— Low production of new vessels and their maintenance.

Tourism

Since 1988 tourism has been the fourth largest source of foreign exchange in Indonesia. In 1994 Indonesia received more than four million foreign visitors, who collectively have spent an estimated US$ 4.6 billion in foreign exchange during their travels in the archipelago. In 1998 Indonesia ranked as the sixth tourist destination in Asia. Since 1995 the growth of tourism in Indonesia was an impressive 17.8% per year. Indonesia has abundant resources for the development of marine and coastal tourism, including white sandy beaches, coral reefs, island ecosystems. A number of beach and island resorts have been developed and can be reached relatively easily from the main gateway cities of Medan, Jakarta, Surabaya, Denpasar, Menado, and more recently also Batam, near Singapore. It is projected that tourism will overtake oil and gas as the principal sources of income within the next decade.

Developing the Indonesian capability in marine science

Introduction

The basis for the various maritime industries is a strong marine science and technology capability. Serious efforts in the development of a marine science and technology capability started in 1974, when six leading universities were requested to develop marine science and technology as their primary programmes. These universities are: University of Riau (Riau Province, Sumatra), Bogor Agriculture University (West Java), Diponegoro University (Central Java), Hasanuddin University (Makassar, South Celebes), Sam Ratulangi University (Menado, North Celebes) and Pattimura University (Ambon, Mollucas). In addition, two technical institutes (Bandung Institute of Technology and Surabaya Institute of Technology) have been assigned to develop marine engineering and technology. After twenty years, these universities and institutes now start to produce enough excellent graduates. They are the main source of man-power in the marine sector.

Parallel to the man-power development, the Indonesian government also started to develop modern infrastructure and facilities for marine research through the State Minister of Research and Technology since the early 1980's. Research stations were founded in eastern Indonesia (Ambon; Iran Jaya; Bitung, North Celebes) and additional ones will be established in the near future in western Indonesia (Natuna Island, South China Sea; Malacca Strait; West Sumatra).

Indonesia has also sent thousands of young and bright students abroad. They were trained in Europe, USA, Japan, Canada and Australia, and acquired advanced degrees in various fields. In addition, Indonesia skilfully utilised many opportunities of developing its marine capacity through bilateral co-operation, with among others. The Netherlands, France and the UK. Apart from the Snellius II related training programme, The Netherlands hardly took hold of the opportunity which the training of young Indonesian marine scientists, engineers and technicians offered to strengthen the relationship between the two countries. Yet, The Netherlands has a lot to offer in the field of maritime and marine activities.

Snellius II Programme (1982-1987)

In the 1980s the Dutch and Indonesian governments provided funding for the Snellius II Programme (1982-1987). Within this bilateral partnership the Netherlands Council for Oceanic Research and the Indonesian Institute of Science (LIPI) implemented a joint research programme in the eastern Indonesian waters. By this, the Dutch government complied to the request of the Dutch marine scientific community to develop an ocean-going research capability in The Netherlands and on the other hand, used the execution of this major research initiative as a policy instrument towards this community in allowing the dispersed community of scientist and scientific institutions to overcome internal conflicts of interest. The Snellius II Programme was highly successful and lead to on-going investment in marine research. However, controversies at a national level together with a changing responsibility for the national co-ordination in the 1990s, resulted in decline of ocean-going research. At present the ocean-going activities more or less stabilised at the 1975-level.

The innovative element of the Snellius II Programme was that transfer of knowledge and capacity building formed an intrinsic part of the overall programme, as well as the conversion of the results to the public at large, politicians, and policy makers. The Snellius II Programme started in November 1982 and ended exactly five years later with a scientific symposium in Jakarta. The most spectacular phase of the programme was an expedition of sixteen months in 1984-85. The expedition was executed by the Dutch research vessel *Tyro* (fig. 3) and five smaller Indonesian research vessels, a helicopter and a small plane. Research was organised in five themes: (1) geolo-

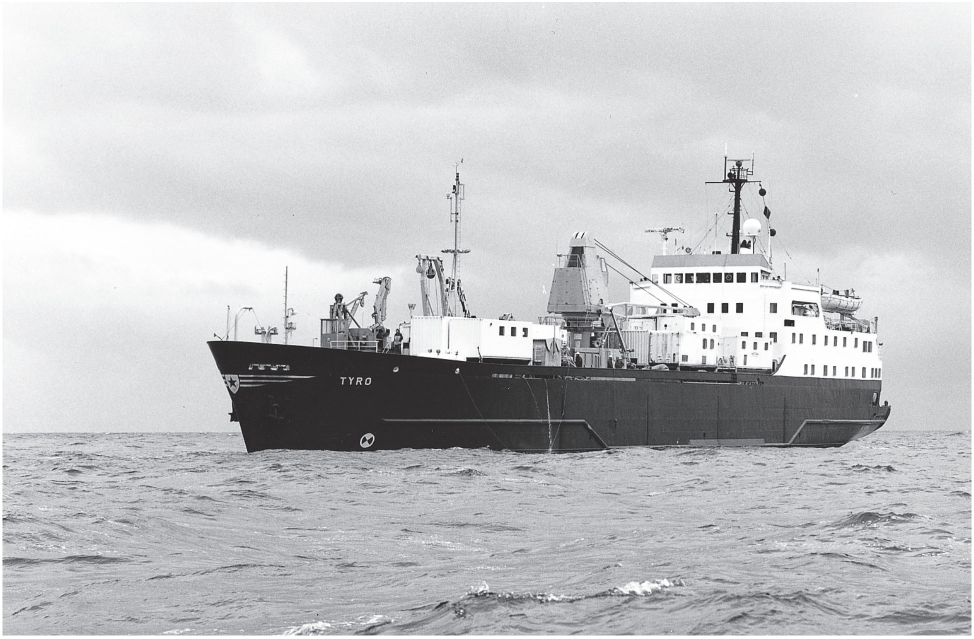

Fig. 3. The containerised research vessel “Tyro” served the Dutch research community from 1982-1994, and formed the basis for the Snellius II Programme (1982-1987).

gy and geophysics of the Banda Arc, (2) ventilation of deep-sea basins, (3) pelagic systems, (4) coral reefs, and (5) river input into the ocean. More than 200 Dutch and some 250 Indonesian scientists and technicians participated in the programme. The scientific output comprised some 300 papers in refereed journals and the development of the concept of *Partners in Marine Science*, now applied by international organisations such as the Intergovernmental Oceanographic Commission of UNESCO and the Organisation for Economic Co-operation and Development, as well as an increasing number of bi- and multilateral development agencies. Within this concept the transfer of high quality scientific know how and capacity building activities are linked in a long-term (5 to 10 years) partnership between developed and developing countries.

The use of containers as mobile research laboratories on board a fully containerised research vessel, was an important factor in the success of the expedition. This idea was developed in The Netherlands during the late seventies to take advantage of a national pool of oceanographic equipment, allowing both small academic departments and governmental research institutes to execute ocean-going research projects. Standard twenty-foot containers serve as (trans)portable biological, physical, chemical and geological laboratories, workshops, electronic shops, storage rooms and even as specialised laboratory for C^{14} analysis. The ship that was to serve the expedition was the Dutch freighter with passengers accommodation “Tyro”, acquired in 1982. “Tyro” was modified for the use of containers by constructing container lockers, connecting bridges and central supplies for power, salt and fresh water, etc. In addition passengers accommodation was enlarged so that it could carry 15 crew and 25 scientists. Fifteen highly different research cruises were executed during the Snellius II expedition by simply reshuffling the thirty containers stored at the ship's deck and in the ship's holds. Another successful innovation was the use of half a dozen air-conditioned containers as a shore-based laboratory in the harbour of Surabaya and a two-container laboratory at Gresik, some 40 km north of this city. The concept of containerised research laboratories has further been developed through the MOSES (Mobile Station for Environmental Services) project of EUROMAR (Berg et al., 1994). Containerised laboratories form a flexible and tailor-made element in the capacity building process.

Transfer of know-how and educational assistance was an important aspect of the Snellius II Programme. During the programme some 80 plus junior and senior Indonesian scientists came to The Netherlands for technical and analytical training. During the expedition, ship-board training was given for junior scientists and technicians. An analysis of the number of scientists on-board *Tyro* indicates that the participation of Indonesian scientists was substantial (fig. 4). A similar analysis of the number of technicians shows that the participation of Indonesian technicians was low (fig. 4), indicating - as in almost any developing country - the lack of qualified marine technicians. Another important element of the training programme concerned guest lectures by Dutch scientists at Indonesian universities and research institutes.

After the expedition some 70 Indonesian scientists came to The Netherlands in the framework of a special fellowship programme for training on data analysis, data handling and the preparation of joint reports and scientific papers. This programme was made possible by development funding, which was made available through the Dutch Ministry of Education, Culture and Science. Indonesian scientists generally stayed in The Netherlands for a period of three to nine months. Some stayed several years and obtained a PhD at a Dutch university. Today, leading Indonesian science managers refer to this capacity building initiative as 'laying the basis' for the present, advanced Indonesian marine science capability. The ex-Snellius fellows now form the core scientists and lecturers in a number of marine institutions such as the centre for Research & Development (R&D) in Oceanology in Jakarta, the Hydrographic Office

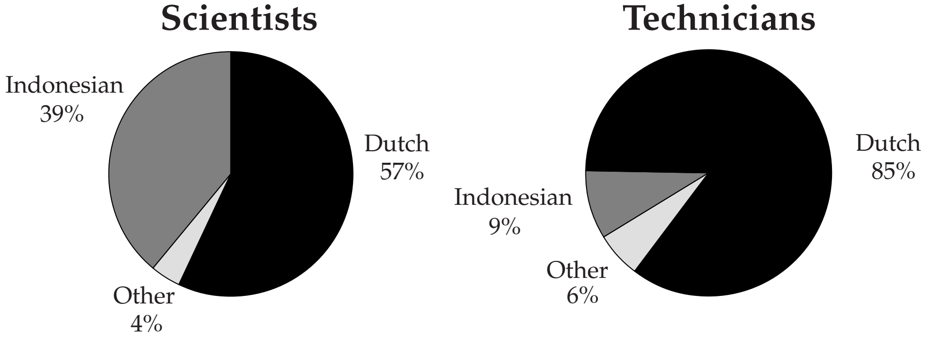

Fig. 4. Number of scientists and technicians during the Snellius II Expedition (1984-1985).

of the Navy, and at universities with a strong programme in marine science. At present the Dutch co-operation with Indonesia is mainly focused on coastal research and management. Plans for a Siboga II Programme did not yet mature.

Developments in the late1980s and 1990s

After the Snellius II Programme, Indonesia continued to strategically invest in marine R&D, through other bilateral co-operative efforts such as:

— The French-Indonesian co-operation in oceanographic research, CORINDON (Coriolis Cruises in Indonesia) campaigns, 1978-1990; JADE (Java-Australia Ocean-Dynamic Experiment), 1990-1995.
— The Japanese-Indonesian co-operation in bathymetric mapping, fishery and mariculture.
— The German-Indonesian co-operation, on fishery stock assessments, geophysics, shipbuilding, etc.
— The UK-Indonesian co-operation in marine science education.
— The USA-Indonesian co-operation in relation to throughflow experiments in the Indonesian waters.
— The Dutch-Indonesian co-operation in coastal research and in coastal zone management.

As an integral part of these capacity building efforts, Indonesia also participated in a number of regional and international programmes, such as the ASEAN (Association of South East Asian Nations) -Australia Coastal Resources Programme, the ASEAN-Australia Regional Ocean Dynamics, the ASEAN-US Coastal Resources Management Programme, the ASEAN-Canada Marine Science programme. Indonesia also has actively participated in the activities of the Sub-Commission for the Western Pacific of the IOC (WESTPAC), and international research programmes such as TOGA (Tropical Ocean and Global Atmosphere), WOCE (World Ocean Circulation Experiment) and CLIVAR (Climate Variability Programme).

Infrastructure development

Following the French Indonesian cruises with “Le Coriolis”, an agreement was signed for the construction of a number of research vessels for Indonesia in France. This project was partly funded by a loan and partly by a grant from the French government. Indonesia now operates four ocean going research vessels (BRT 750), being the “Baruna Jaya I - IV” for respectively oceanography, bathymetric mapping, multipurpose activities and geophysics, and fisheries. The “Baruna Jaya V” and “Baruna Jaya VI” were constructed in France, the “Baruna Jaya VII” for coastal resources surveys, has been constructed in Surabaya, Indonesia. The most recent vessel of the series, the “Baruna Jaya VIII” was built in Norway. The last two ships are run by LIPI, whereas the others are operated by the navy. All ships bear the name of ‘Baruna Jaya’. ‘Baruna’ is in Sankrit the name of a mythical Sea God, while ‘Jaya’ means ‘the Great’.

In 1998 Indonesia deployed twelve Seawatch buoys in the western parts of the archipelago (fig. 5). Seawatch is an on-line, of-the-shelf environmental monitoring

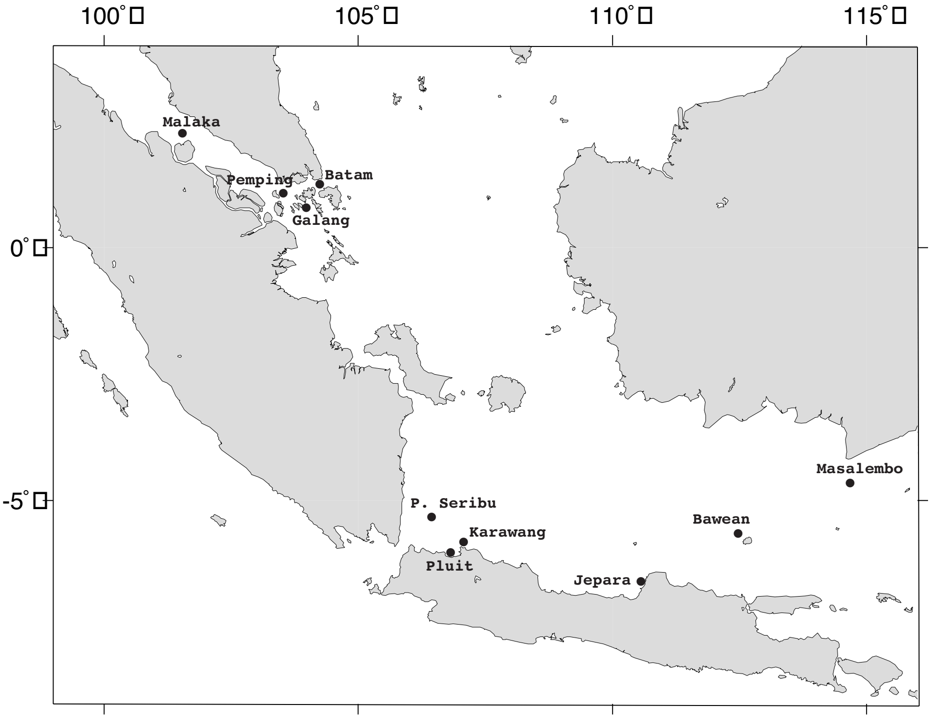

Fig. 5. The location of the present Seawatch buoys in the western part of Indonesia.

and surveillance system (fig. 6). Seawatch was developed to provide an operational marine environmental surveillance and information system for the management of regional seas (Hansen & Stel, 1997). It consists of the following modules: data acquisition, data storage, analysis and presentation, environmental modelling and forecasting, distribution of data, forecasts and user relevant information. The data acquisition module includes a network of moored marine environmental data collection buoys. The Seawatch met-ocean buoy (fig. 6) is a vertical stabilised automatic buoy. The buoy is presently equipped to collect the following parameters: air pressure, air temperature, wind speed and direction, wave parameters, sea current velocity and direction, vertical temperature and salinity profile, oxygen saturation, nutrient contents, particle or algae concentrations and radioactivity. As the buoy is made as a flexible system, suitable new sensors can be included as soon as they become operational. The buoys also include data logging equipment, on-board processing (data analysis, quality control) and a data transmission system. The data are transmitted through a two-way satellite communication system (ARGOS or INMARSAT) to a shore-station.

At the shore station the data are further checked, analysed, distributed and stored. The buoy data are integrated with information from other sources (satellites) as input to various numerical models, such as current, transport and oil slick models. Results from these models are combined with information from the buoy network to generate user-tailored forecasts. One important aspect of the system is the use of the

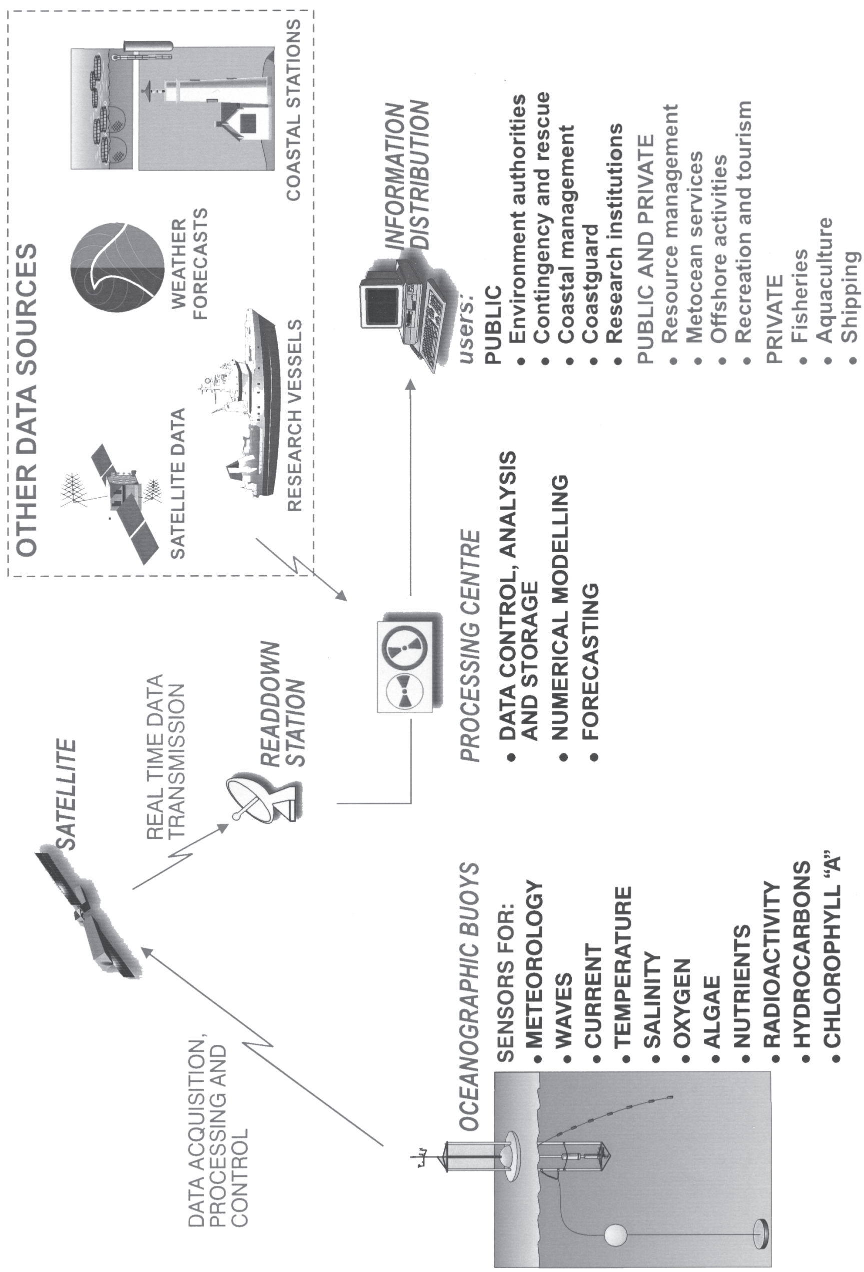

Fig. 6. The Seawatch system is a state-of-the-art, off-the-shelf marine monitoring and forecasting system. It is a building block for the Global Ocean Observing System and the Monsoon Observing System.

data with operational forecasting models for ocean currents, pollution transport and impact assessments. All data and results from the various models, are collected in a processing centre where the results are quality checked, and thence used for monitoring and forecasting purposes. This centre could be compared with processing centres in weather bureau's.

The Seawatch programme is a co-operation between Indonesia and Norway. During the first phase Norway provided the monitoring sensors, while Indonesia constructed the buoys. Later, however, Indonesia also intends to manufacture the sensors. The Seawatch system as well as other facilities, will be part of the Indonesian contribution to the Global Ocean Observing System (GOOS) which is a joint effort of the IOC of UNESCO, the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP). GOOS will provide long-term oceanographic data based on a globally co-ordinated strategy. GOOS will be based on the results of research programmes which identify strategies, modelling needs, and new technologies. The system will be built as far as possible on present global, regional, and national systems through an integrating process. GOOS will consist of a number of modules to address specific objectives such as: (1) climate assessment and prediction, (2) marine living resources, (3) coastal zone management and development, (4) health of the ocean, and (5) marine meteorological and oceanographic operational services. It is meant to provide a reliable description of the state of the ocean, which will be regularly updated and will serve as an input to a wide range of operations, such as coastal protection, marine resource exploitation, safety, monitoring the marine environment, and pollution control, and will also be used in other international and regional programmes. The Indonesian Seawatch monitoring system could, when the political situation in the region allows for it, be linked with similar systems in Vietnam, Thailand and India, into a regional South East Asian GOOS (SEAGOOS) system (Stel,1997). Such an initiative could catalyse the development of GOOS in the northern and equatorial Indian Ocean and lead to a better understanding and predictability of the monsoons in the Indian Ocean region. It would also play a key role in the development of the Monsoon Observing System (MOS) as proposed by the CLIVAR research community (Lau et al., 2000). Both GOOS and MOS will be justified by the improved climate forecasting of the Asian-Australian Monsoon System as well as improved weather forecasts (improved tropical cyclone prediction, improved prediction of the start of the monsoon rains, etc.) and other non-climate related processes (fisheries, harmful algal blooms) within the Indonesian ocean space.

Policy instruments

Science and technology are indispensable requirements for national development. In most developing countries science and technology are therefore strongly integrated with national development. To ensure this, the Indonesian State Minister for Research and Technology has established in 1984 a National Research Council (Dewan Riset Nasional) through a Presidential Decree. One of the functions of this Council was to prepare and monitor the implementation of National Priority Programmes on Research and Technology Development. Government agencies, research institutions and universities may develop proposals within the framework of the Priority Programmes.

Marine scientific research is a prerequisite for a rational development and man-

agement of the marine resources and the protection of the marine environment. To optimise management of Indonesian seas, an inter-departmental committee has been established. This was the National Committee for Ocean Technology, composed of experts and administrators from various fields of expertise coming from various research institutions, government agencies and universities. The long term objectives of this committee were:
— To develop an indigenous capability to live from and with the sea.
— To develop marine resources to support the national development in terms of equal income distribution.
— To manage marine resources and coastal areas for a long term socio-economic gain.

The main functions of these objectives are:
— To formulate a general policy for marine science and ocean technology development.
— To formulate national programmes, to co-ordinate and to execute the system management of all activities related to marine scientific research and ocean technology.
— To monitor all activities related to these fields.

An inter-disciplinary and inter-agency programme based upon the National Priority Programmes on Research and Technology was formulated. The programmes concentrated on: (l) surveys and mapping (general bathymetric mapping, mapping for navigational lanes and the delineation of national borders at sea), (2) inventory and evaluation on marine resources (e.g. fisheries, energy, minerals), (3) studies of the marine environment (e.g. oceanographic features of Indonesian and adjacent waters, coastal development and management, monitoring of marine pollution), and (4) coastal and ocean engineering, including the development of capabilities in underwater technology and offshore engineering. These programmes were supported by three cross-cutting programmes, namely: (1) manpower development, (2) the establishment of a National Oceanographic Data Centre, and (3) the development of a relevant research infrastructure.

One of the priority sectors in the Sixth Five year Development Plan (REPELITA VI: 1993-1998 was the Maritime Development Programme. Unfortunately, marine related activities are scattered in various sectoral departments, non-departmental agencies, as well as at various universities. To co-ordinate these activities more effectively, a high level co-ordinating council was established at the end of 1996, the National Council of Marine Affairs (Dewan Kelautan Nasional). The Council was chaired by the President of the Republic of Indonesia with the co-ordinating Minister on Defence and Security as the vice chair/daily executive. Various ministers responsible for marine related programmes activities were members of the Council.

Very recently, under the government of President Wahid a new Ministry for Maritime Exploration and Fisheries has been formed to explore and develop the overwhelming potential of the Indonesian ocean space, covering some 5.8 million km^2 (including the EEZ). Through this ministry, which is headed by Minister Sarwono Kusumaatmaja, research and exploration, capacity building and the development of marine and maritime related institutions, protection of the sea, coastal zone management and fisheries are priorities for the near future.

Conclusion

The Indonesian government realised that science and technology is a pre-requisite for national development. Therefore, a planned effort for national capacity building in marine science and technology has been carried out consistently since the 1970s. Bilateral, regional and international co-operation was an integral and important part of the capacity building effort. The marine sectors have contributed substantially to the national development during the First Long Term Development Plan (1969-1994) of Indonesia. It is expected that this contribution will be enhanced during the second Long Term Development Plan (1995-2020). Indonesia now operates a marine science and technology capability consisting of highly qualified personnel, state-of-the-art institutes, modern oceanographic vessels, a complete Seawatch system in the western part of the archipelago, access to satellite data, etc. The Indonesian example clearly demonstrates that the development of a marine capacity for curiosity drive and applied research is a long-term affair. Capacity building includes man-power development (scientists, technicians and administrators), the development of an enabling environment, investment in marine technology (instruments, ships, etc.), data handling, etc. (Stel, 1997). The Indonesian example also demonstrates the need for political backing of the capacity building process. At the beginning of the third millennium sustainable development of ocean space is a key and fascinating element of the Indonesian 'maritime concept'. Implementing this new concept might result in Indonesia becoming one of the world's leading countries in marine research & development.

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