Twelve years as master of the *SA Agulhas*

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INTRODUCTION

The *SA Agulhas* (Fig 1) was conceived as a replacement for South Africa's Antarctic research and supply vessel, the *RSA*, in 1977. She evolved from a combined project involving the Department of Transport as the owner, the CSIR, the UK firm of Burness, Corlett and Partners as the naval architects and the Japanese shipbuilding firm of Mitsubishi Heavy Industries as the eventual successful contractor for the building. The keel was laid in the Shimonoseki ship yard on 14 June 1977. On 30 September 1977 the vessel was launched by the wife of the then Minister of Transport (Mr SL Muller), Mrs Hanlie Muller.

SA Agulhas was built to the highest possible standards of Lloyds of London and is rated +100 A1 Strengthened for Navigation in Ice. After a short period of trials in Japanese waters she set sail on 31 January 1978 for South Africa under the command of Captain Funk, the long-time master of the *RSA*.

After arrival in Cape Town the vessel loaded stores, equipment and personnel for her maiden voyage to Marion Island. The ship departed on 7 April 1978. Captain Funk served as shipmaster until his death in 1979 when I took over. I have been *Agulhas*' master ever since.

TECHNICAL INFORMATION

Vital statistics and mechanical details

SA Agulhas' vital statistics are shown in Table 1. The sophisticated engine room is one of the most impressive areas on the ship (Fig 2). The main propulsion system comprises two Mirlees Blackstone, medium-speed, diesels each rated at 2 240 kw. These drive a single controllable pitch propeller *via* a Lohmann & Stolterfort twin input/single output gearbox. This gearbox reduces engine revolution output from about 600 RMP to a 230 RMP shaft speed. The relatively high propeller speed has considerable advantages when working in ice as it allows milling of ice on contact with the blade rather than slow battering. Consequently propeller damage is limited provided that high revolutions are used at all times.

Fig 1 The mv SA Agulhas

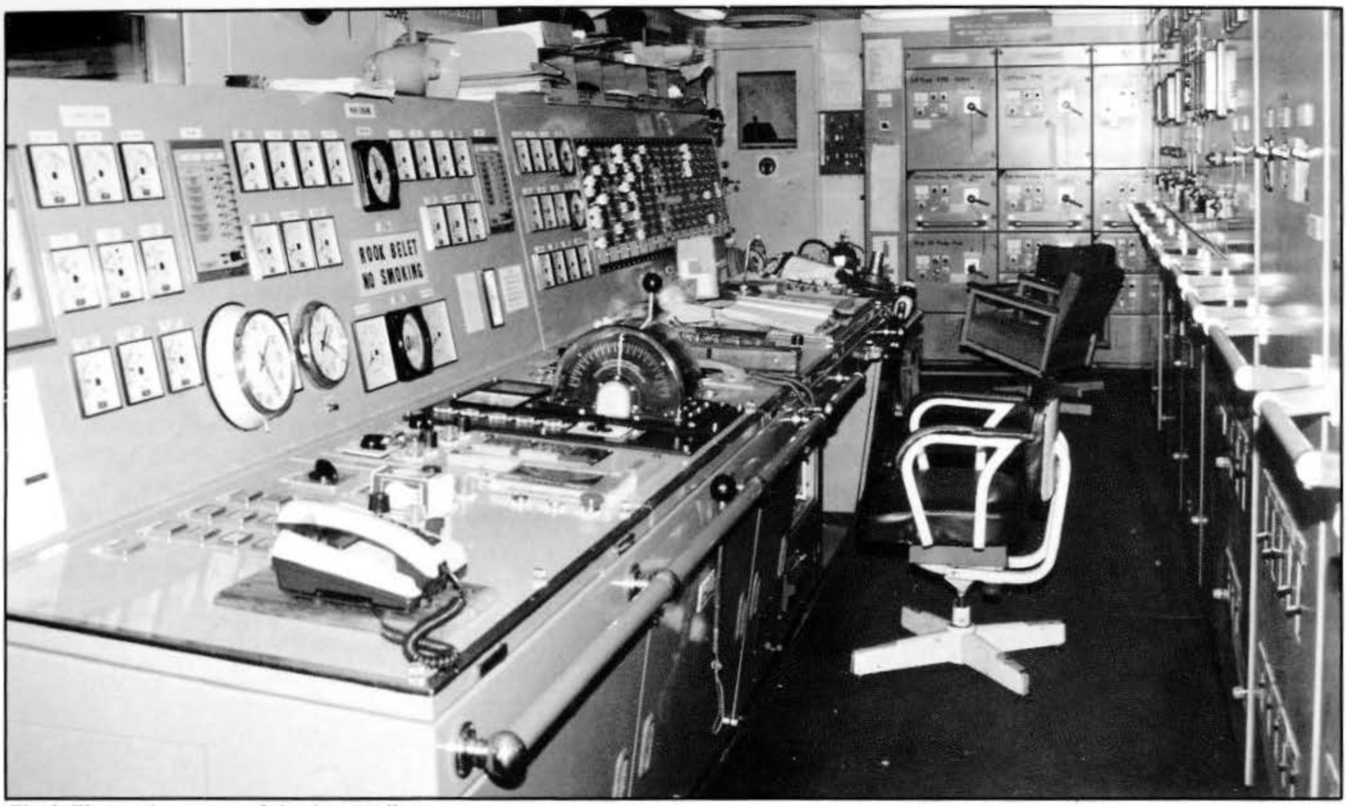

Fig 2 The engine room of the SA Agulhas

Three Diahatsu 6-DS-22 diesels drive closed air-circuit water-cooled alternators to produce 975 kVa. Any single alternator is capable of sustaining the vessel's normal demand load under most operational conditions.

Air-conditioning is provided for both polar and tropical operations. Heat is generated by two thermal fluid heaters that force warmed air through the vessel's three independent air-conditioning units.

Complement/Accommodation

The ship has a complement of 16 officers and 25 crew and at the time of delivery possessed accommodation for 98 passengers. This was reduced to 94 in 1980 when one of the four-berth passenger cabins was converted to a wet laboratory adjacent to the oceanographic and hydrographic winches. At present, passenger accommodation consists of three VIP two or four-berth cabins, three single cabins, seven double and 15 four-berth cabins (Fig 3). One of the single berth passenger cabins was taken over to accommodate an additional electronics officer soon after the ship's delivery. All cabins have their own shower and toilet facilities and are of an adequate size to accommodate persons taking passage on short voyages to and from the bases on Marion and Gough Islands and the South African National Antarctic Expedition (SANAE) base on the Fimbul Ice Shelf. Ship-based personnel are usually accommodated in double berth cabins or placed two per four-berth cabin. Room for recreational facilities is provided. These include a bar and television room. These facilities, however, have proved to be somewhat inadequate over the years, especially when a large complement of passengers is on board. These shortcomings will be addressed during the 1992 refurbishment programme.

At the time of going to press, the refurbishment programme was well underway and there is little point in describing the existing laboratories and research facilities in any detail. However, a brief description will be useful to obtain a better perspective on the proposed facilities described later.

Presently, the laboratories are spread over three decks. On the bridge deck are four spaces, two of which are used to house

Fig 3 A four-berth cabin aboard the SA Agulhas

navigational and meteorological instrumentation. The remaining two are used as laboratories on oceanographic voyages. The balloon room and three further laboratories are housed on 02 Deck. Amidships on the upper deck are two winches for vertical sampling and a rudimentary wet laboratory (previously a cabin). Aft are two laboratories — one for general purpose and the other fitted for geophysics research. There is also a large coring winch, accommodating 10 000 metres of cable.

Fuel storage and cargo-handling

As originally designed, the ship was built with a capacity for 650 tonnes of her own fuel and a further 400 tonnes of cargo fuel. Over the years it has become necessary to increase this and additional fuel tanks were built to provide a further 400-tonne capacity. The vessel thus now has an endurance of over 75 days at full speed.

Space for dry provisions and victualling stores, meat and fish are sufficient for over 100 days. Surplus cargo space of 110 m^3 of freezer capacity is available to extend this. The overall cargo space of 4 100m^3 is provided for in three holds served by a five-tonne travelling deck crane and a 25-tonne Orenstein and Koppel fixed crane on the foredeck. The original 30-tonne Thompson derrick was replaced in 1989 when it became obvious that it was incapable of delivering a 25-tonne Caterpillar tractor onto an ice shelf in excess of about 20 m high. All the cargo holds are easily accessible by virtue of their large hatch openings and can be opened or closed hydraulically by a single operator.

Operational characteristics and details

The vessel is extremely manoeuvrable thanks to incorporation of both bow and stern thrusters. The bow thruster is of the J Samuel White type and has no exterior fittings that could be damaged by ice. It consists of a large, hydraulically driven water pump that forces water through a directional gill under the keel whereby water flow can be directed 360° in 30° steps. In the event of rudder failure the system can be used for steerage and under good conditions is capable of propelling the ship at speeds up to 3 knots. The provision of spares for the system has proved problematical since the manufacturers have gone out of operation and it is therefore extremely noisy when operating at full thrust.

The stern thruster is of the conventional type and comprises a hydraulic motor that drives a propeller situated in a tunnel through the vessel, thus allowing the direction of thrust to be changed from side to side. The thruster tunnel is sealed by large doors on either side. These prevent the ingress of ice when proceeding through pack ice and limit cavitation when steaming in open water. The doors have proven to be a weak point in the vessel's design as they are relatively inaccessible when at sea and can only be maintained in the dry dock. Consequently, any faults with the doors limit manoeuvrability until dry-docking is possible. Over the years it has thus been necessary to operate without the stern thruster for much of the time.

Because of the requirement to operate in ice while minimising hull damage, it was not possible to fit the vessel with active stabilisers or bilge keels. To limit rolling, therefore, *SA Agulhas* was fitted with a Watts type, roll-damp system. This consists of a large, built-in tank situated close to the vessel's centre of gravity. A predetermined amount of water is pumped into the tank and its free movement from side to side is restricted by baffles that cause the movement of the water to be out of synchronisation with the vessel's roll. The propensity to roll is thus considerably dampened. A major shortcoming of the roll-damp system however, is that at particular rolling periods and frequencies, the baffles do not work effectively. As a result the rolling movement may actually increase, which results in considerable discomfort for those on board and necessitates rapid dumping of the tank's contents. In particular, it is often found that when running survey transects at least one transect is positioned such that the swell comes from a direction that is incompatible with the safe operation of the roll-damp system. Heavy rolling for the duration of this particular transect leg thus becomes an occupational hazard.

SA Agulhas is fitted with extremely sophisticated fire detection and fire-fighting systems. These have been added to over the years and are kept in excellent working operation. In accordance with Department of Transport regulations fire and boat drills are carried out every week in various parts of the vessel. All safety equipment is kept up to date with current international regulations, although the vessel has to comply to the newest set of regulations which took effect in July 1991.

Navigation

The navigational equipment originally fitted was very good at the time the vessel was commissioned, but since then more modern and efficient systems have been developed. The result is that navigational-wise the vessel is not as up to date as she could be, although some upgrading has occurred over the years.

For instance, a more modern SATNAV has been installed as has a GPS unit. A modern ARPA radar plotting system was installed in 1989. This has greatly enhanced the vessel's navigation capabilities, especially during ice navigation as well as for helicopter control. The entire navigation system is to be extensively upgraded during the refurbishment programme.

Table 1: The *SA Agulhas'* vital statistics

OVERALL LENGTH	109.45 m
BREADTH	18.00 m
DEPTH	7.50 m
DRAFT	6.05 m
GROSS TONNAGE	5353.13 T
NET TONNAGE	2 599.44 T
SUMMER DISPLACEMENT	7107.00 T

Helicopter operations

The most significant and obvious features of the vessel's profile is the large hangar and flight deck fitted aft. The hangar accommodates both the vessel's Aerospatial "Puma" (J Model) helicopters (Fig 5) in addition to all the necessary spares such as spare blades, engines, toolboxes, folding gear washing systems, etc. Each side of the hangar is fitted with a travelling two-tonne crane that facilitates engine removal/replacement and the carrying out of other minor repairs. A high-pressure washing system is also available to remove salt water from the aircrafts' fuselages, thereby minimising corrosion. *SA Agulhas* carries 89 tonnes of AVCAT fuel internally for the helicopters and this can be supplemented by from additional stocks carried in drums in the holds. A special self-tensioning system is fitted for handling the helicopters in rough weather and there are numerous tie-down points fitted on the deck to hold them during strong winds or severe deck movement. A very efficient communications system


Fig 4 A Puma (Model J) helicopter aboard the SA Agulhas

is available and this covers HF, VHF, (AM) (AERONAUTIC), VHF (FM) Marine bands and VHF (FM) private bands. VHF direction finder, HF direction finder and MF ADF are all fitted to ensure safe operation of the helicopters even in the most adverse flying conditions. Recently both the helicopters and vessel were fitted with X-band radar transponders. These allow the detection, identification and control of the helicopters above the radar horizon and up to 40 or 50 miles away.

SOME PERSONAL IMPRESSIONS

At the end of 1991, *SA Agulhas* completed her 65th voyage. Many of these voyages have comprised more than one leg so it is rather difficult to adequately assess the full extent of the vessel's involvement in research in the Southern Ocean. She will however have steamed well in excess of 425 000 nautical miles and spent over 2 100 actual days at sea (not including time standing off the bases). Initially *SA Agulhas* spent about 210 days per annum at sea. This has been reduced to a current level of between 150 and 160 days per year as a result of financial constraints and the cancellation of a second voyage to Marion Island each year. The vessel's schedule thus requires a 75-day voyage to relieve the SANAE base every year commencing in late November or early December, a relief voyage to Marion Island in April/May of 40 to 50 days and the relief of the Gough Island Base in September/October. The latter is combined with a call to Tristan da Cunha and lasts about 40 to 50 days. The duration of all the voyages are to a large extent dependent on scientific requirements and the amount of work required to be done by the Public Works Department at the various bases. In addition, a number of dedicated research cruises have also been undertaken between the Antarctic continent and South Africa.

Work at the islands

From the above schedule it should be obvious that one of *SA Agulhas'* major functions is to resupply South Africa's various bases in the Southern Ocean and Antarctica. For this reason the handling and efficient discharge of cargo has come to assume a major part of the vessel's operation. The primary method of cargo discharge at the islands is by large inflatable rafts that are towed ashore by one of the vessel's two workboats. Two rafts were initially inherited from the *RSA* and these are still in use after some 20 years of service. In fact they were condemned four years ago since they were leaking badly and had almost as many patches as original material. As soon as the new replacement rafts arrived, however, it was found that using the rafts in tandem instead of single not only improved the efficiency of cargo discharge but also enhanced the safety of the raft crews. The recent arrival of a further two new rafts has finally allowed the original rafts to be retired at long last.

The only problem to have arisen from the modified raft procedure described above is that whereas the workboats were initially required to tow an eight-tonne raft, they are now towing one of 16 tonnes. This has necessitated the pensioning off of the old workboats and re-engining of the newer ones. The original 25 hp workboat engines were replaced by 50 hp Atlantis diesels and have proven to be most effective and safe.

The discharge of the cargo is unfortunately both labour intensive and time consuming since the entire ship's complement and those scientific staff who are not part of the relief team are involved. Eight crew are located in the boats or rafts at any one time and about five or six people are required in the hold to move the cargo out from the wings and onto the cargo nets that are loaded to about 1 tonne per net. Each net is secured with rope lashings to prevent the contents from falling out. Only one net at a time can be lifted by the crane since the raft crew are required to secure the net under somewhat precarious conditions as a result of both raft and ship movement. During cargo-handling at the islands, ship's time is adjusted so that the working day commences with local sunrise at 08h00. This allows every man to get a good warm breakfast before he starts work.

The crew working in the rafts are all issued with a wet suit that they wear under an overall and a working lifejacket. At Marion, water temperature is normally about 6° to 8° and the wind is in excess of 50 knots. Although wind *per sé* does not limit cargo-handling operations, it does make life in the workboats most unpleasant since the crew in both the boats and on the rafts are constantly sprayed by cold salt spray, snow or hail. Choppy sea conditions also make it difficult to maintain footage and salt-water rashes on the neck and face are regular complaints. If swells reach in excess of about three metres, loading of the rafts as well as working under the crane hooking on the load becomes impossible. The ship then has to lie off and wait for improved conditions.

The ship seldom lies at anchor at Marion Island during the night as winds are very changeable and on the few occasions a night has been spent at anchor the vessel has been forced to claw its way seaward after a strong onshore wind has made the anchorage untenable. For this reason the vessel drifts off the island's lee at night, steaming on occasions when the swell makes sleeping uncomfortable. Early in the morning, *SA Agulhas* closes to the base so as to have the anchor down by 08h00 when the crew commence cargo-loading by placing the rafts and boats in the water. This usually takes about 30 minutes followed by another 45 minutes to load a raft depending on the number of people working in the hold. On good days, cargo is handled on the basis of five rafts under the crane every four hours. Since work is carried out from first light to darkness this usually results in movement of something like 250 tonnes of cargo per day. On occasion this figure is exceeded, although in rough conditions it is often not even closely approached. It usually takes about three days to discharge all the cargo apart from fuel that is pumped ashore towards the end of the vessel's visit.

On Marion Island itself, the cargo crane jib is about 30 metres above the water line. This means that the rafts are required to lie alongside the rocks during loading and offloading. The approach to the mooring site is at right angles to a rocky cliff and is situated in rather shallow water. With a two to three-metre swell running, the approach has to be very carefully calculated as moving in too close is likely to result in both boat and raft getting caught in the breakers thereby being cast onto the adjacent rocky beach. A quick backdown after a second right-angle swing sees the raft slide sideways into the cliff where the raft is secured by a fixed mooring line with the workboat pushing the raft into the cliff with her stern. Missing the mooring requires the boat to haul away quickly and attempt a second approach. Once the raft is secure the work boat releases the raft and stands by to quickly retrieve the situation should an emergency (e g a broken mooring line or man overboard) occur. Prior to 1980 the mooring position was even more dangerous due to the presence of a rock close to the cliff. In heavy swells the boats used to strike this rock and finally a team of divers from the South African Navy blasted off the top 1.5 m to make navigation in the area much safer.

At Gough Island the discharge is similar to that at Marion except that the discharge crane is about 70 m above the water. The crane driver is positioned on a rock archway on the other side of the mooring position and some 50 m above it. The discharge of cargo is much slower than at Marion due to the extra lifting distance and a slower crane rate. Other additional dangers are evident at Gough. For instance at Marion should a boat or raft go ashore there is a reasonable chance of walking away. At Gough, however, should a raft break free or the boat engine fail then the craft is likely to be carried into a small cave adjacent to the landing site where the swell breaks onto some sharp rocks. Chances of survival are minimal although ambient water temperatures (13 ° to 14 °C) are somewhat higher than at Marion.

Fig 5 The SA Agulhas *in Antarctica*

Fuel is discharged at both islands by anchoring *SA Agulhas* very close inshore using two anchors and then running a 75-mm layflat hose to the shore where it is connected to the manifold. Fuel is then pumped ashore at a backpressure of about 7,0 bar and at a rate of about 30 tonnes per hour at Marion and 15 tonnes per hour at Gough. The speed of discharge is much lower at Gough since it is necessary to lift the fuel so much higher. Pumping usually takes all day with the workboat running the hose ashore while air is pumped into the line to keep it afloat and to ensure that it is open all the way to the tanks. Very little leakage is tolerated and even a small leak usually results in immediate replacement of the hose section in which the leak occurs, even though this is a very difficult operation. Prior to recovery, the hose is blown through with air on completion of pumping to clear it of any residual fuel oil. The final oil dregs in the hose are drained into a drum in the recovery boat whilst the hose is reeled in.

The alternative method for discharging cargo is by helicopter with cargo either being stowed inside the helicopter or slung underneath it in nets. The first method is slow as the helicopter is required to land on deck. The cargo is then loaded before the helicopter flies to its destination, lands and is then unloaded. This method is used, therefore, only when cargo has to be moved some considerable distance or the cargo is very fragile or valuable. One advantage of this method, however, is that the helicopter can fly at full speed and consequently the cargo ferry time is relatively rapid. Helicopter landing and launching are however restricted to conditions when ship's roll is no more than 5°, pitch no more than 2° and the wind envelope is limited to 15° to 30° on either bow with the wind speed less than 40 knots.

The second method requires that the cargo be pre-loaded aboard *SA Agulhas* into nets that are weighed and stacked in a flying-off sequence. The ship is manoeuvred for flying over the foredeck and the helicopter being used is fuelled so as to fly off the cargo amount prepared. For safety reasons each net load is calculated so that the helicopter can fly approximately 95% of the payload each flight and thus as fuel is consumed the weight of cargo is increased proportionately.

When flying cargo off the foredeck, the vessel must be positioned with the wind on the starboard beam, between 75° and 90° off the bows. The vessel also has to be kept as close to the landing site as possible to limit the flight time. As a result the vessel is manoeuvred with the wind on the beam, using the thrusters to minimise drift, within about one quarter to one half a nautical mile of the landing site. With an experienced pilot it is possible to move approximately two tonnes of cargo every three minutes over half a mile and fly the helicopter for about 75 minutes between refuelling. It then usually takes about 90 minutes to prepare the next sortie as the cargo has to be broken out, loaded into nets, weighed and lifted onto the loading platform. It is thus possible to move between 200 and 250 tonnes a day in this way.

The work at SANAE

In Antarctica, three different methods can be used to discharge cargo. The most ideal and quickest is to get to the permanent ice-shelf early enough in the season when the fast-ice (i e the bay-ice) is still connected to the shelf and where an embayment (or bukta) has formed. At the juncture of the bay-ice and ice-shelf the shore party built a ramp down to the bay-ice. At SANAE, the ice-shelf is about 20 to 25 metres high and the cutting out of a ramp comprises pushing ice over the ice edge and then slowly building it up until the incline is sufficiently low to allow a D6 Caterpillar tractor to tow two loaded sledges to the top. This entire procedure can take up to 5 days but it is hoped that in future the process will be speeded up with more powerful tractors using rippers to cut away the snow faster before the bulldozer pushes it onto the bay-ice.

Manoeuvring the vessel is very difficult during cargo-handling in the ice since to lay abeam alongside the ice requires constant thruster use. Furthermore, the vessel cannot tie up to the shelf as the shelf height of more than 20 m does not permit the correct mooring rope leads to be made. In addition, the area of water directly adjacent to the shelf is very dangerous since small cracks in the ice edge can cause the shelf to give way and so, depositing a large quantity of ice into the vessel's open holds, possibly sink her. Since the ice-shelf does not have a straight vertical edge, a ram of ice juts out under water into the open water nearby. This constitutes a further hazard, since the ram may come into contact with the vessel's plating below the waterline where it is not as thick as at the bow and is weakened by the bilge turn. The consequences of serious damage to the hull are obvious. Finally, transferring weights from one side of the ship to the other with the crane induces listing and rolling. Should the superstructure contact the upper levels of the ice shelf this could cause windows to crack, damage the very thin plating of the accommodation, damage the lifeboats and buckle the bulwark plates and flight deck. For this reason, the vessel only lies alongside the ice shelf to land heavy vehicles and moves close into the shelf for each lift.

The second method of cargo discharge makes use of the helicopters. Depending on the nature of the payload, discharge can be either from the helicopter deck or the foredeck. The procedures followed are, by and large, similar to those used at the islands. The current loading record in Antarctica for one day (bearing in mind that 24 hours of daylight prevailed and that fuel drums, an easy loaded cargo, constituted the bulk of the cargo) is 390 tonnes using two helicopters and three helicopter crews. The helicopters are also very valuable for ice reconnaissance and for ferrying personnel ashore to support the shore operations. Further details of these operations are given in Theron *et al* (this volume).

Re-siting the forward crane to the forecastle will create the third discharge option and will enable the bows to be nudged up against the ice, as is done to pump fuel. Loaded sledges will then be lifted off the loading platform onto the shelf where they can be towed away. This will also mean that it will be possible to reduce the number of people on the dangerous shelf edge and any breakaway of ice will cause relatively less damage since the rudder and propeller will then be situated some 100 m from the ice.

Scientific support

Despite having as her prime function the servicing of South Africa's bases, *SA Agulhas* undertakes some form of research on every voyage. For example, countless weather buoys have been deployed, meteorological balloons have been released at 12-hourly intervals on every voyage and meteorological reports are transmitted every three hours when at sea. The neutron monitor has been collecting data for 13 years while thousands of Expendable Bathythermographs (XBT) have been fired from the poop-deck. Over a quarter of a million miles of ocean-soundings have been made for the Naval Hydrographic Office and for the General Bathymetric Chart of the Oceans (GEBCO). Inshore hydrographic surveys have been carried out at Marion, Gough, Bouvet, Tristan da Cunha and the South Sandwich Islands. The data collected has been given to the Hydrographic Office for inclusion in new editions of the charts for these areas. A number of new sea mounts have been discovered and several, previously unknown, underwater features identified.

Much of the marine science research undertaken from the ship has been done as part of relief voyages and consequently scientists have to plan their research to fit into the time available. However, as mentioned above, certain dedicated scientific voyages have been undertaken. These include the FIBEX and SIBEX components of the BIOMASS programme and physical oceanographic studies into the Agulhas current retroflection area. These cruises were manned by both local and international scientists.

The future

As mentioned earlier, *SA Agulhas* will undergo a major refurbishment and upgrading during 1992. The programme has as its objectives the improvement of the ship's systems, cargo-handling facilities, passenger accommodation and a major upgrading of its research facilities.

The navigation and communication systems will be considerably enhanced with the fitting of a new radar echo-sounder and GPS equipment. Data from the equipment will be integrated and displayed on a new navigation console. New communications equipment includes full SATCOM facilities and a satellite-receiver for weather/sea surface data.

It is also hoped to improve the recreational facilities on board by extending the passengers' lounge to accommodate more people and seat them in a high-density seating arrangement. Additional areas for television-viewing will also be provided for. An expanded gymnasium will be built.

In addition to the re-siting of the 25-tonne crane, other ship systems will also be improved. These include the fitting of waste heat recovery units to reduce the quantity of fuel used to provide heating in the accommodation and the upgrading of refrigeration equipment. New lifeboats will also be fitted.

It is in the area of scientific facilities that the upgrading will be most apparent. A new oceanographic complex is to be created amidships and will comprise a wet laboratory, an operations room and a chemical laboratory. The spaces will be served by two new slipring winches and a telescopic arm. The poop-deck is to be rearranged to accommodate an A frame at the stern and a new twin drum towing winch with slipring facilities. The resiting of the coring winch has facilitated the creation of a completely new suite of five laboratories. The meteorological laboratory is to be re-sited close to the balloon room, the latter having been enlarged. New equipment to be installed include a CTD/rosette, thermosalinograph, scientific echo-sounder and data logger/processor and a purpose built data distribution system, displaying navigational, meteorological and scientific data in all laboratories and on the bridge. The computer equipment and electronic workshop are to be housed in a refurbished laboratory on the bridge deck.

In my twelve years as master of *SA Agulhas*, I have seen the vessel become more efficient while operating in what must be one of the most extreme environments in the world. The planned refurbishment will not only extend the vessel's operational life, it will allow the reputation it has built for itself to be further enhanced.