

OPERATIONAL PROBLEMS OF WAYERIDER BUOYS IN HIGH FLOW AREAS

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ABSTRACT

National Institute of Oceanography, Goa undertook wave measurement programme using Datawell waverider buoys at three locations in the northern part of the west coast of India and at one location in the Godavari estuary where high current speeds varying from 2 knots to 5 knots were observed. As a consequence of prevailing high currents, significant drag forces were experienced by the waverider buoy and its mooring system causing occasional submergence of the waverider buoy. The paper highlights some of the mooring systems and their components adopted in an attempt to reduce the drag forces on the waverider buoy systems thereby preventing the submergence of the waverider buoys. A successful technique adopted for replacing the waverider buoy using the original mooring system for attaching the new buoy in the high flow areas in the Gulf of Cambay has been discussed.

INTRODUCTION

Deployment and operation of Datawell waverider buoys in high flow areas of coastal waters need special consideration in the selection of various mooring assemblies and their handling. Strong currents increase drag force acting on the various mooring components like rubber cord, mooring rope and the waverider buoy. Standard mooring recommended by the manufacturers wherein rubber cord is attached immediately below 70 cm waverider buoy can be used in waters where current speed does not exceed 2 knots. For current speeds between 2.5 to 3.5 knots, the manufacturers recommend that the rubber cord be attached near bottom anchor so that low bottom currents may considerably reduce the drag force on the rubber cord. The 90 cm waverider buoy giving high buoyancy is recommended for use when surface currents exceed 2 to 3 knots.

The National Institute of Oceanography, Goa undertook wave measurement programmes at the three locations in the north-west coast of India as shown in Fig. 1 where high flow conditions exist and at another location in the Godavari basin where high currents were observed particularly during the high flood discharge from the river. In the gulf areas

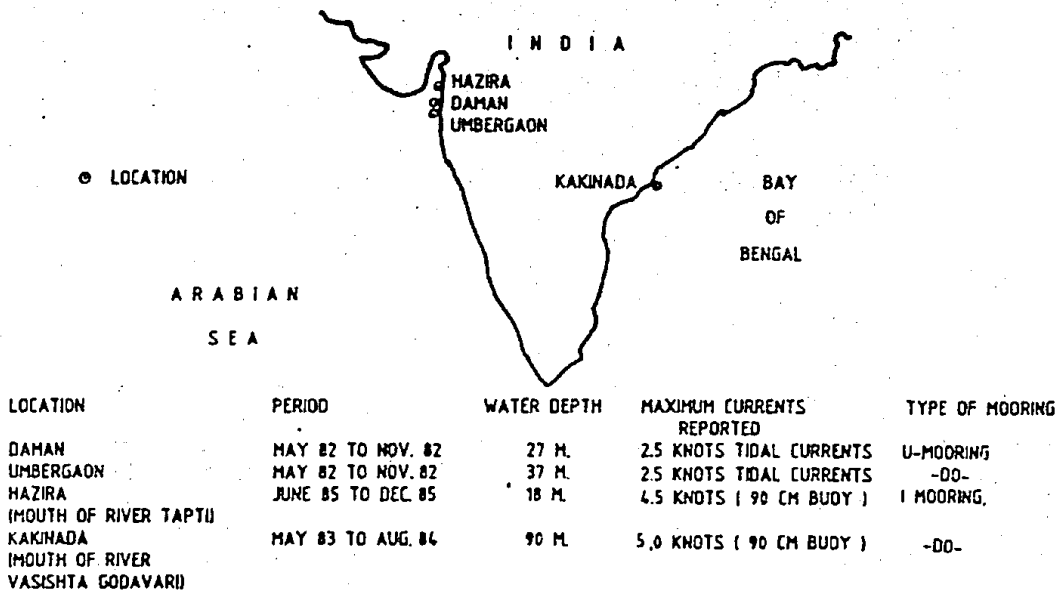


FIG. 1 LOCATION MAP OF WAVE DATA COLLECTION

of the Gujarat coast, drifting fishing nets were abundantly used by the local fishermen while in the Godavari basin trawler operations were predominant. The high fishing activities in the area of waverider location posed several problems in regard to safe operation of buoys. A locally available mechanised boat of 12 to 16 meters length, say a trawler having a derrick boom and a winch of about 2 tonne capacity was selected for handling waverider buoys.

WAVERIDER MOORING

In the waverider mooring, introduction of an elastic element like the rubber cord and the use of mooring rope of optimum thickness helps to reduce the effective drag on mooring line and enhances the free floating ability of the waverider buoy. The U-type of waverider mooring (Fig. 2) was adopted when rubber cord was positioned near anchor end and I-type of mooring (Fig. 3) was adopted when rubber cord was positioned near waverider end. The drag force DF acting on the mooring line in a water flow of velocity V m/sec and its vertical and horizontal components are shown in Fig. 4.

The Morison's equation for drag force can be written as,

$$DF = \frac{1}{2} \rho \cdot A \cdot V^2 \sin^2 \theta \cdot C_D$$

and the vertical component

$$V_{DF} = DF \cdot \cos \theta$$

- where
- ρ = Mass density of sea water in $\text{Kg Sec}^2 \text{m}^{-4}$
 - C_D = Coefficient of normal drag
 - A = Projected area in m^2
 - θ = Angle between the mooring line and horizontal

Vertical downward load V_{DF} acting on the mooring line causes submergence of the waverider buoy. Three different mooring configurations

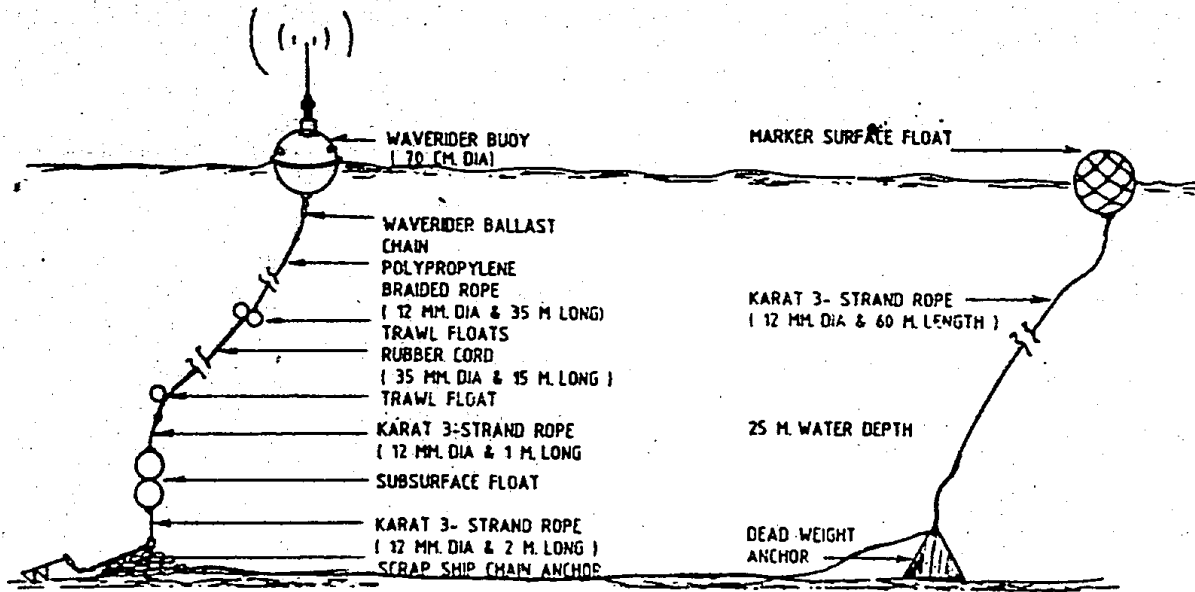


FIG. 2. U-MOORING- RUBBER CORD AT BOTTOM END

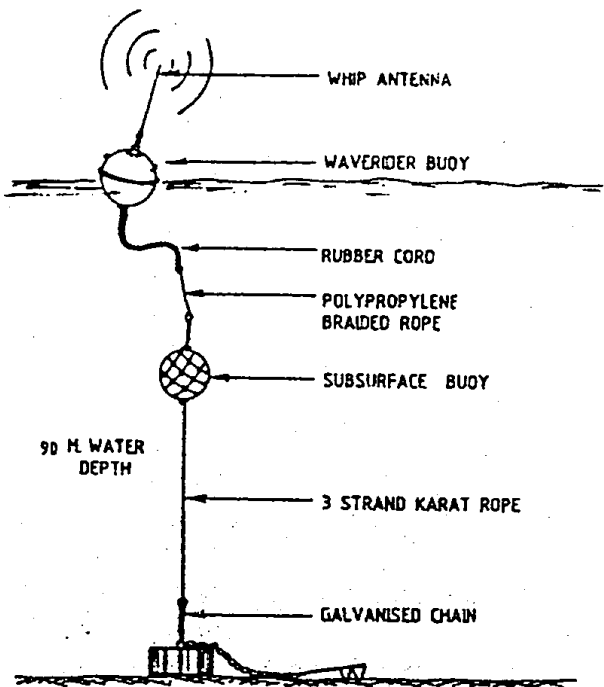


FIG. 3. I-MOORING

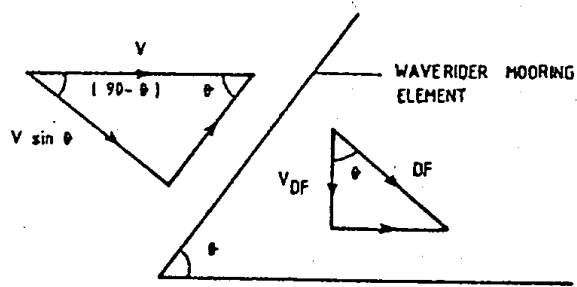


FIG. 4. DRAG FORCE ON MOORING LINE.

as shown in Fig. 5 were selected for comparison of V_{DF} acting on the mooring line. Computed values of V_{DF} are presented in the table- I. It is clearly seen that drag force reduces by about 4 to 6 KgF when angle θ is changed from 45° to 30° .

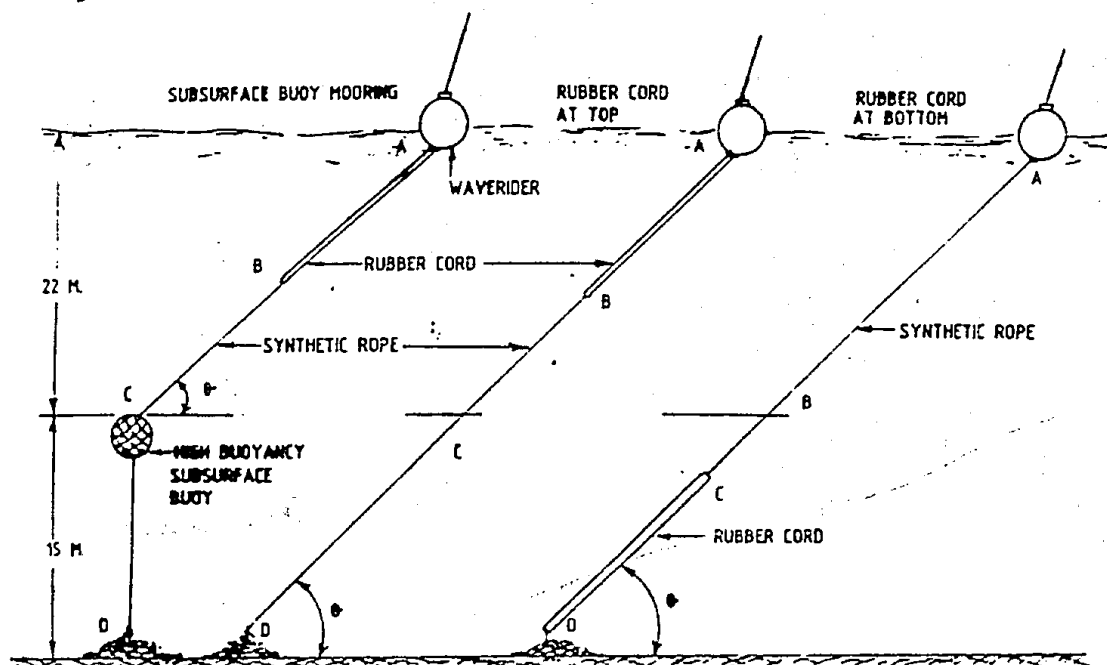


FIG. 5. TYPICAL WAVERIDER MOORINGS CONSIDERED FOR COMPUTATIONS OF DRAG FORCES

TABLE-I: COMPUTED VALUES OF V_{DF} FOR THREE CASES

| Sr. No. | Mooring component for which Drag force is computed (Fig.5) | V_{DF} = Vertical component of drag force in KgF | |
|---------|--|--|---------------------|
| | | $\theta = 30^\circ$ | $\theta = 45^\circ$ |
| 1 | Waverider mooring upto the sub-surface buoy. | 18.51 | 24.82 |
| 2 | Rubber cord at top | 22.04 | 28.81 |
| 3 | Rubber cord at bottom | 18.17 | 22.37 |

Assumptions: (a) Average current speed V from the sea surface to 22 m depth is taken as 1.25 m/sec and average current speed V at depth below 22 m upto the bottom is taken as 0.85 m/sec.

(b) Coefficient of normal drag C_D for rubber cord and synthetic rope is 1.2; assuming them to be smooth cylinders.

(c) Rubber cord diameter $d = 0.035$ m, length $L = 15$ m.

(d) Synthetic rope diameter $d = 0.012$ m.

- (e) Drag force acting on submerged part of waverider is not considered as it is the same for all the cases used for comparison.

Datawell waverider buoys of 70 cm or 90 cm diameter were used depending upon the current speeds prevailing at the location. The 90 cm diameter waverider buoy was deployed in the Godavari basin where surface currents of the order of even 5 knots were observed during the southwest monsoon. 90 cm diameter waverider buoy was deployed off Hazira where dominant tidal currents of the same order as above are observed throughout the year. The 70 cm waverider buoys were used off Daman and Umergaon as 90 cm buoys were not available at the time of the project implementation.

Rubber cord and three strand karat rope attached to the waverider buoy form the sinking component of the mooring system. The critical drag area $C_D.A$ of rubber cord is about 2.5 times greater than that of the fully submerged waverider buoy ($C_D.A$ for waverider = 0.26 m^2 and $C_D.A$ for rubber cord = 0.63 m^2). From Table I, it can be seen that shifting of rubber cord nearer to the bottom anchor reduces the vertical component of drag force by about 6 KgF when mooring line makes an angle of 45° with the horizontal.

Initially 70 cm diameter waverider buoy deployed off Daman, Umergaon and Kakinada were found to submerge during the spring tide periods (Fig. 6) when current speeds exceeding 2 to 2.5 knots were observed.

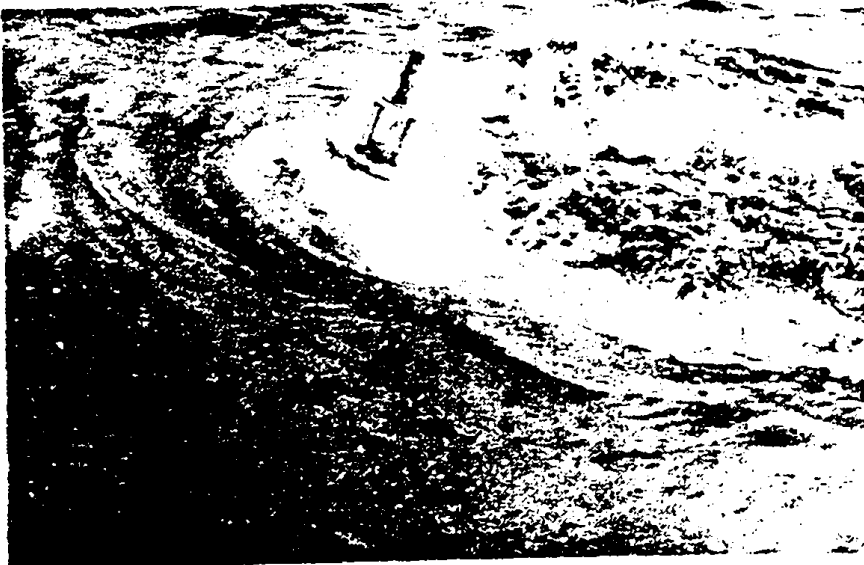


FIG. 6: SUBMERGENCE OF WAVERIDER BUOY OFF KAKINADA

Shifting of rubber cord close to the bottom anchor enhanced the free floating ability of the waverider buoy and satisfactory wave data could be recorded at all the sea states. The U-type of mooring was adopted (Fig. 2) at these locations for doubly ensuring the recovery of the rubber cord and the waverider buoy. Besides waverider buoy, the sub-

surface float used below the turbulent wave zone and a piece of braided polypropylene rope used in the slack part of mooring line form the floating component of the mooring (Fig. 2 & 3). By connecting a suitable subsurface buoy in the mooring (Fig. 3) below wave noise zone the total effective length of mooring rope responsible for causing vertical downward load on the waverider buoy is significantly reduced. Thus it enables the waverider buoy deployed in greater depths to float freely during high current periods. Table I shows that the use of subsurface buoy in the mooring line, reduces the V_{DF} by about 4 Kgf when rubber cord is positioned at the top.

While 70 cm diameter waverider buoy was operational off Nokinada during non-monsoon period, lot of sea weed/plants carried by river flow got entangled with the mooring line of the waverider buoy and a lot of barnacle growth (Fig. 7) took place all along the length of the line. As

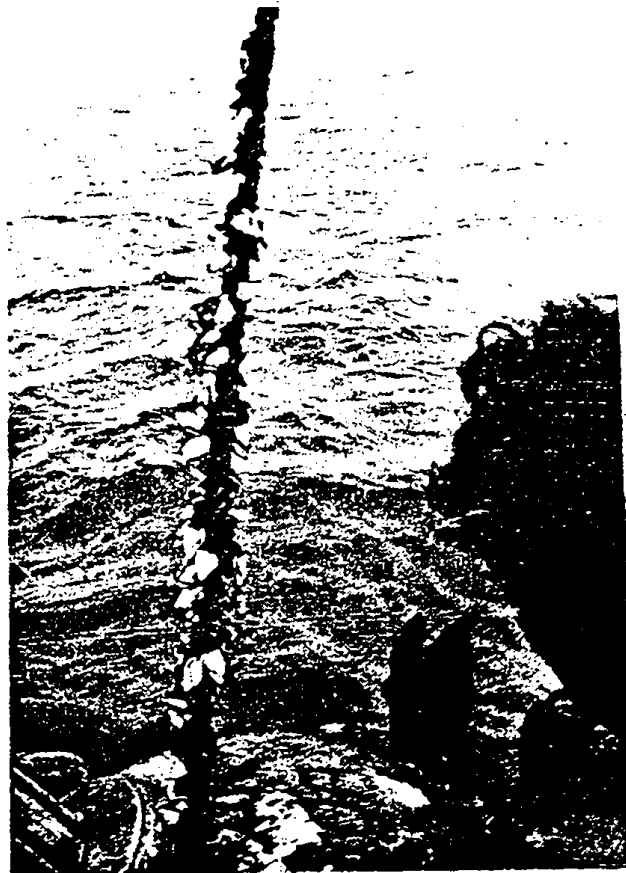


FIG. 7: GROWTH OF BARNACLES ON MOORING ROPE.

As a result the heavy drag force was exerted on the rope, thereby the waverider buoy started submerging very frequently. When the mooring line was cleared from seaweeds/plants, free floating ability of the waverider buoy was restored.

M. S. scrap ship chain links were used as dead weight anchor at

the bottom. The sea bed at Daman, Umbergaon and Hazira is silty and has a gentle slope. Hence, use of auxiliary embedment anchor along with ship chains was necessary for preventing drifting of the mooring system due to strong currents prevailing in these locations.

Anchor last method was adopted for the waverider buoy deployment. During the deployment or retrieval operation, utmost care was taken to see that no sharp edges of the boat rub against the mooring line including rubber cord, as the scratches caused by the sharp edges may prove to be dangerous to the mooring line which is under tension due to action of strong currents and waves.

MEASURES FOR SAFETY OF WAVERIDER BUOY

At waverider buoy locations of Daman and Umbergaon, the fishing activity with the help of large drifting nets and trawlers was very intensive. Hence, to prevent vandalism or theft of the waverider buoy, a watchkeeping boat was anchored in the vicinity of the buoy (Fig. 8).

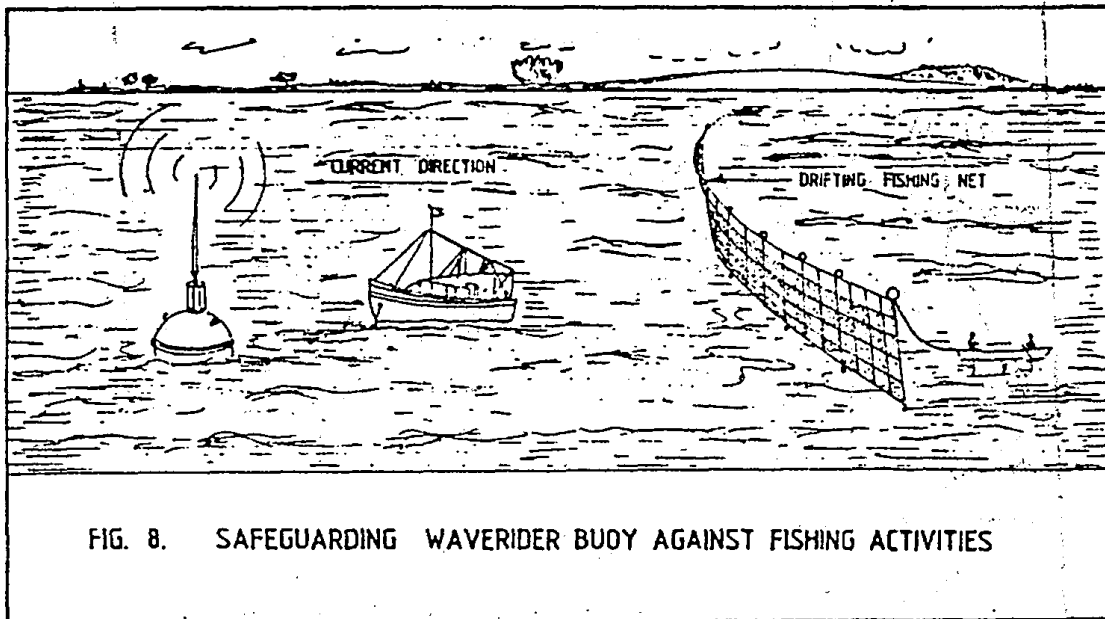
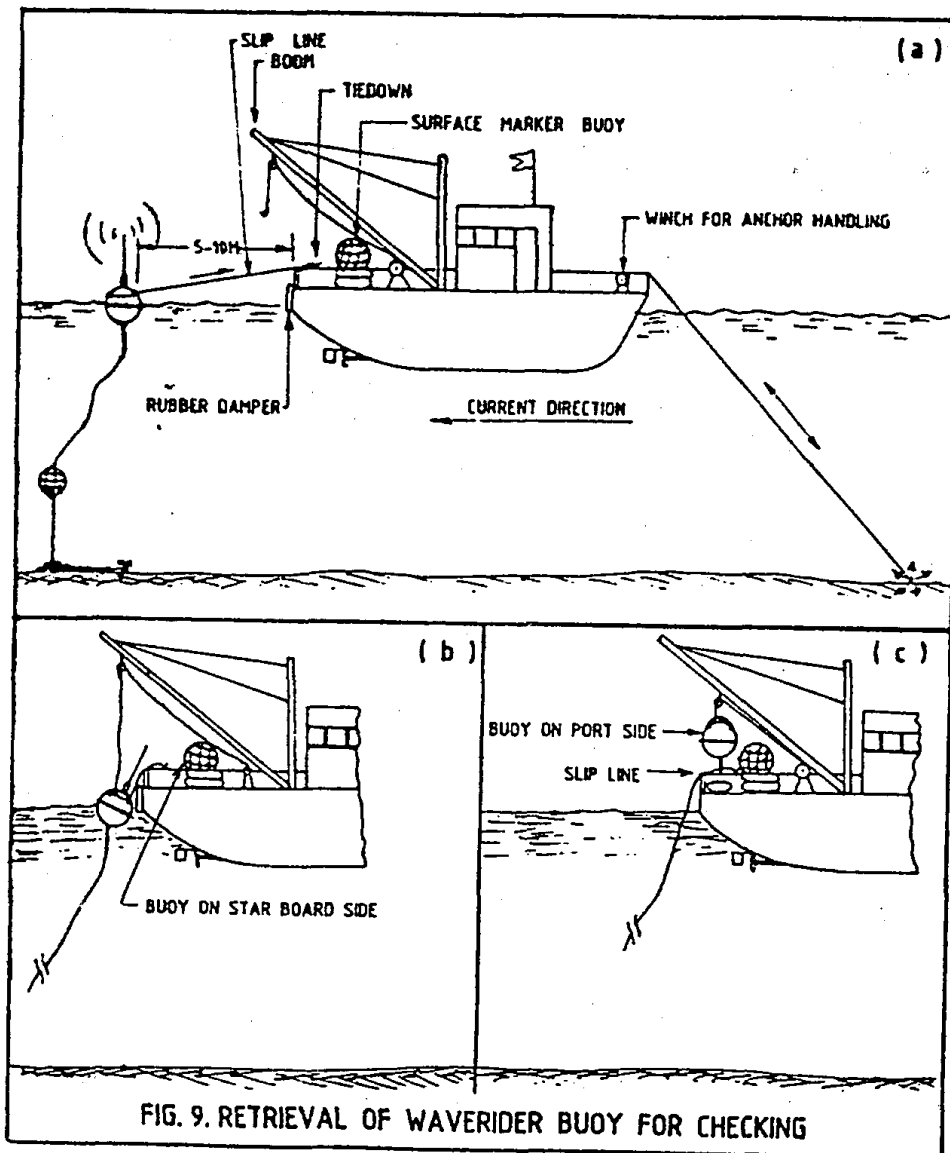


FIG. 8. SAFEGUARDING WAVERIDER BUOY AGAINST FISHING ACTIVITIES

The 90 cm diameter buoy deployed off Hazira developed pitting on its hull. It was decided to operate the same buoy with pitted hull after applying protective painting. The buoy was operated successfully from June 85 to Dec. 85 with periodic checking at about 2 months interval and repainting of the hull when found necessary. During these operations, it was necessary to retrieve the waverider buoy. A surface marker buoy was used at the location so that the same mooring could be used for mooring the waverider buoy after inspection and repainting.

During retrieval operation, a boat anchor with adequate holding power was dropped little away from the waverider buoy. By positioning the stern of the boat facing towards the buoy, anchor rope was manually controlled so as to take the boat astern to within 5 to 10 meter distance from the buoy. During changing of buoys, careful manoeuvring of the boat was necessary to prevent excessive tension and stretching of the

rubber cord. A slip line was tied to the loop made on the waverider buoy (Fig. 9 a) and it was pulled towards the boat. The rubber fenders mounted on the stern of the boat protected the buoy against possible damage by hitting and rubbing against the boat hull. Care was taken to avoid spinning of the buoy. After removing whip antenna, the waverider buoy was hauled up on the boat deck using derrick boom and winch (Fig. 9 b). Then the rubber cord was unshackled and connected to the large marker buoy kept ready on the deck. As an additional safety measure a fairly long polypropylene rope was tied on the upper detached end of the rubber cord and other free end of the rope was tied to the tie down on the boat (Fig. 9 c). After this surface marker buoy was connected to the rubber cord terminal and dropped carefully in the sea. The detached waverider buoy could thus be taken to the shore for inspection, repairs and repainting of the hull etc. Later the same waverider buoy was redeployed by replacing the surface marker buoy.



DISCUSSIONS AND CONCLUSIONS

The success of wave data measurement using waverider buoys in the high flow coastal waters depends upon the free floating ability of the waverider buoys under all weather conditions. Based on the experiences gained during wave measurement program at NIO, the following conclusions are made:

By the introduction of the rubber cord at the anchor end, the 70 cm waverider buoy could be operated even at rough sea conditions with current speeds upto 2 knots. When the buoy has to be operated over extended period of time, monitoring of the mooring line, subsurface buoy and waverider buoy against marine growth etc. would be essential, as it tends to increase the drag force on the waverider buoy. Use of a subsurface buoy particularly in deeper waters would be essential to reduce the drag and downward pull on the waverider buoy.

When the waverider buoy is to be operated over an extended period of time, it can be detached from the mooring line after attaching a surface marker buoy to it. The detached waverider buoy can be inspected for batteries or faulty electronics etc. before attaching it to the same mooring line. If proper care in choosing the mooring hardwares is taken at the time of initial deployment, the same mooring line could be used for repeated short-term deployment of the waverider buoy.

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