BAY OF BENGAL PROGRAMME

DEVELOPMENT OF SMALL-SCALE FISHERIES

TECHNICAL TRIALS OF BEACHCRAFT PROTOTYPES IN INDIA

BOBP/WP/7

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PREFACE

This is the first report of technical trials conducted in India of four beachcraft prototypes designed for India's east coast fisheries. The trials were held in May-June 1980 in Ennore, 20 kilometres north of Madras, under the auspices of the Bay of Bengal Programme, in cooperation with the Governments of Tamil Nadu and Andhra Pradesh.

The report briefly discusses the limitations of traditional craft operating on India's surf-beaten east coast and the desirability of developing new types of craft with greater carrying capacity and productivity. It discusses the additional considerations — as regards such matters as the shape of the boat, the construction material, the systems of surf-crossing and beachianding —that must weigh in the design of surfboats. It describes in words and pictures the four prototypes tested in Ennore, the conduct of the trials and the findings they yielded.

The trials covered only surf-crossing and beachlanding. Of the four prototypes, two — considered the most promising — were selected for intensive fishing trials. The report sets down the relative merits of the four prototypes.

The report may serve to keep governments, development agencies and boatbuilders informed about the progress of development of beachcraft. It may also be of interest to small-scale fisheries planners in general.

The prototypes were built at Aquamarine (P) Limited, Madras; Indian Seacraft, Madras, and the Andhra Pradesh Fisheries Corporation Boatyard at Kakinada. Diesel engines were supplied by Greaves Lombardini Limited, Madras.

The Bay of Bengal Programme engaged two consultants for the project— Mr. øyvind Gulbrandsen of Norway, who designed the prototypes, and Mr. G. P. Gowing of Australia who assessed their surf-riding qualities. They worked with R. Ravjkumar, fishing craft specialist of BOBP. The Directorates of Fisheries of Tamil Nadu and Andhra Pradesh participated in the project as cooperating agencies; Mr. Varadarajan from the Department of Fisheries, Tamil Nadu, served as a liaison officer for the trials. From Andhra Pradesh, Mr. S. B. Sarma, Inspector of Fisheries, participated in the trials along with six fishermen from Kakinada. Four fishermen from Ennore village constituted the main crew.

The beachcraft development project is an activity of the Bay of Bengal Programme for the Development of Small-Scale Fisheries, referred to in brief as the Bay of Bengal Programme. It is executed by the Food and Agriculture Organization of the United Nations (FAQ) and funded by the Swedish International Development Authority (SIDA). The main aims of the BOBP are to develop and demonstrate technologies to improve the conditions of small-scale fishermen and the supplies of fish from the small-scale sector in five countries that border the Bay of Bengal — Bangladesh, India, Malaysia, Sri Lanka and Thailand.

The document is a working paper and has not been officially cleared either by the Government of India or by the FAO.

CONTENTS

1 INTRODUCTION

1.1 Beachlanding craft account for the bulk of fish landings in India. On the east coast there are, according to the 1973-77 census, 64,000 non-mechanised craft which operate from 860 villages situated mainly at exposed beaches along the coast. About 140,000 fishermen utilise these traditional craft. Including their families, about 560,000 people are directly dependent on such craft for a living.

1.2 Nearly three-quarters of the traditional craft operating from beaches are kattumarams. These craft are virtually unsinkable and their main structural components are very strong, so they are well suited to landing on wave-beaten beaches and crossing surf; they can be carried by their crews up and down the beach, being easily dismantled, if necessary, into their component parts. Their disadvantages include a rather low carrying capacity in relation to empty weight, and lack of protection for crew and catch. Only very large kattumarams (kolamarams stay at sea overnight. The range is normally limited by carrying capacity and by the fact that their method of propulsion is by sail and oar or paddle. The catches of individual craft tend to be small and production per fisherman is low.

1.3 It is desirable to improve the standard of living of the small-scale fisherman of the east coast of India. One of the ways of doing this may be to improve production per man at sea. On the existing fishing grounds, this means more effective fishing methods, and at present this seems to mean carrying more gillnets or more hooks per man, which the existing kattumaram cannot conveniently do, nor could it safely carry the resulting bigger catch.

1.4 Increasing productivity per man at sea, is, moreover, one way of releasing labour for the additional work on shore that would be necessary if higher prices are to be obtained for the catch by packing and processing for more distant markets. If total catch can be increased, the opportunity to exploit more distant markets will be all the greater. but again this would require an increase in production per man, if we assume that it is unlikely that the number of seagoing small-scale fishermen can be increased in the short term.

One way of increasing the total catch of marine fish on the east coast of India is by exploiting grounds further offshore. This cannot be done by building fleets of conventional motor fishing boats because of the lack of harbours and sheltered anchorages. There is therefore a requirement for a craft with longer range than the traditional types but still capable of operating off a surf beach. To compensate for the greater distances to be travelled, once again the requirement is for a craft that can carry bigger catches, which in turn means more fishing gear. Operating at longer range also implies longer fishing trips and hence a greater need for protection for crew and catch and storage space for food.

1.5 It may be possible to increase productivity by adopting mechanical propulsion. Very few kattumarams are at present so equipped. The weight of the engine and fuel further reduces the already low carrying capacity, while adding to costs. To compensate for the additional costs, and provide extra profit for the venture, the craft must again be capable of carrying bigger catches, which again requires more fishing gear. Mechanical propulsion would also increase the ability to range further afield when so desired.

For these reasons, an attempt to develop a mechanically-propelled beach landing craft for use from surf beaches on the east coast of India, and with greater carrying capacity and better protection for crew and catch than the traditional kattumaram, seems to be justified.

The intention is not a complete replacement of traditional craft as this would be too difficult to achieve in the foreseeable future.

2 THE TECHNICAL REQUIREMENTS

2.1 Environmental

2.1.1 The east coast of India between Point Calimere near Sri Lanka and Pun in Orissa, a distance of over 800 miles, is mainly a succession of exposed beaches interrupted by occasional river estuaries and deltas; there are very few harbours, natural or artificial. The beaches are beaten by surf resulting from the breaking of ocean waves originating far out in the Bay of Bengal.

The surf is usually higher in the northern part of the coast. Between Kakinada and Calingapatam, measurements taken by the Meteorological Observatory in 1950-55 indicate only 15 per cent of days with wave heights of less than 0.75 m (2½ ft); most of the time wave heights of up to 1.8 m (6 ft) were observed. Conditions are at their worst during the monsoons.

2.1.2 The wave height is an indication of the energy in the waves, but the rate at which it is dissipated is governed by the underwater slope of the beach. Where this is very gentle, the surf zone is wide, and most of the wave energy is dissipated in a spilling breaker before it reaches the shoreline. Where the slope is steeper, the surf zone will not be so wide, but the wave energy is released rapidly from a wave moving at high speed which becomes a plunging breaker as it nears the shoreline. Some beaches are so steep that the swell reaches the shoreline without being noticeably slowed down or changed; the result is a plunging breaker that breaks on the face of the beach with great violence. Any floating object is hurled on to the beach and carried out again by the strong undertow to be taken by the next breaker.

2.1.3 The beaches from which fishing craft have to operate are generally of the intermediate type. That at Ennore where the trials to be described below were carried out, has a slope of about 20 degrees. Often, at the top of the beaten zone, above high tide mark, there is a crest, on the side of which farthest from the sea the beach slope is more gentle. Beachlanding craft have to be got over this crest before they can be considered safe from possible damage by the sea.

2.1.4 An additional hazard on this coast is a current running parallel to the shoreline at speeds of from 1½ to 4 knots.

2.2 The Technical Problem

2.2.1 The operation of coming in from sea on such a beach can be regarded as comprising the following stages:

- negotiating the surf under control.
- hitting the beach with a more or less severe impact depending on whether the final approach was under control, partially controlled or uncontrolled.
- securing boat, crew, gear and catch against being taken by the undertow, or by the current parallel to the shoreline.
- moving the boat, crew, gear and catch to safe positions beyond the crest of the beach.

When setting out to sea, the sequence of stages is:

- moving boat, crew, gear and supplies to the water's edge.
- getting the boat afloat and immediately under control despite the wave conditions and shoreline current.
- negotiating the surf.

These operations impose design requirements that do not arise when operating from harbours or sheltered anchorages. Some of the requirements are conflicting. In addition, the vessel must be at least adequate as a fishing craft.

There are many other parts of the world where beach landing craft are used in the fisheries; in some of these areas the beachlanding fishing boats have in addition to negotiate surf. The east coast of India, however, presents problems of somewhat greater severity and complexity than elsewhere, and this, besides other things, may explain the failure of previous attempts to develop a suitable mechanised beachlanding fishing craft for this coast. These past attempts are described in another paper prepared as part of the present project.

2.2.2 When going towards the beach through the surf zone, it is not always possible to time the run and control the speed of the craft in order that it arrives at the beach without being caught by a following breaker. It is therefore necessary to adopt a design of craft and a method of operating it that will reduce the likelihood of undesirable consequences when caught by a breaking wave.

If the wave breaks immediately behind, the boat will be thrown forward with considerable force and speed, and the end nearest the wave will tend to lift. This may result in broaching and capsize. It requires a high degree of skill in steering and in controlling the speed of the boat to avoid broaching, but it is much easier with some boat designs than others. The desirable features are two: the boat must not tend to become directionally unstable when the after end lifts, thus immersing the forward end more deeply, nor when suddenly acclerated forward by the pressure of the breaker on the after end; second, the boat must be highly manoeuvrable in yaw, or in nautical terms, responsive to the helm. To meet the first requirement, the hull should not have a deep forefoot or narrow, deep vertical sections forward; instead, the bow should be more spoon-shaped (which will also give lift when going out to sea through the breakers). It will help if the disposable load on board (crew, catch, gear) are as far aft as possible, making for a centre of buoyancy well aft of amidships. However, a broad transom is undesirable since it exposes a large area directly to the breaking wave. A moderate transom is acceptable provided that there is sufficient lateral plane (side area under water) aft, which can be accomplished by deep sections or by providing a deep vertical fin that reaches down into undisturbed water. This fin, however, must be retractable when hitting the beach. A high degree of response to the helm will be achieved if a substantial part of this vertical fin area takes the form of a rudder by ensuring good flow to the rudder and by the adoption of special designs of rudder. Another possibility is the use of a steerable propeller such as is common with outboard engines. Yet another is the use of a steering oar.

In some parts of the world, beachlanding boats are operated so that the bows always point into the waves, the boat coming into land stern first and going out to sea bow first. This helps to solve some of the problems at the expense of introducing others, including the need for an additional manoeuvre when coming ashore, and the need for a reversible propeller in the case of a mechanized boat. Double-ended designs are therefore usually chosen for surf crossing.

A stable boat at rest on a water surface not perpendicular to the line of action of gravity — as for example a boat on the sloping side of a large wave — will, other things being equal, tend to rest in an attitude relative to the water surface different from its attitude when at rest on a horizontal water surface: it will be tilted towards the higher part of the slope, thus reducing the freeboard of the part of the boat nearest the top of the slope. A boat for crossing large steep waves should therefore have high ends and a pronounced line of sheer and these features will also help to reduce the shipping of water from the breaking top of the wave.

2.2.3 Nevertheless the designer has to accept that in Indian conditions the craft will frequently take on board large amounts of water from breaking and plunging waves. He must also accept that from time to time the craft will broach and capsize. To minimise the effects of taking water on board and to reduce the chances of a capsize, there are two requirements; first, the craft should be designed to throw off the water quickly; second, it should have an unusually high reserve of transverse stability.

The first requirement is not met by any kind of open boat; although open boats are used for crossing moderate surf in Sri Lanka it is likely that for Indian conditions boats should be fully decked, and the deck so designed as to be watertight and self-clearing. Failure to realise this requirement was probably a contributory cause of the lack of success of earlier attempts to develop surf-crossing boats, since the designs were of the open-boat type. The kattumaram meets the requirement because its buoyancy elements are solid, but hollow watertight buoyancy elements would also meet the requirement. In twin-hulled designs, the central structure must also be self-clearing or self-draining.

The most appropriate way to meet the requirement for a high reserve of transverse stability is to have a high ratio of beam width to length: this also meets the requirement for the craft to be as light as possible. A high freeboard is less appropriate, since it means increased weight and a higher centre of gravity, especially if the crew have to be above deck, as would be necessary in a small watertight boat.

Self-righting designs are possible, but if of a simple sort, are usually deficient in transverse stability; designs that avoid this defect are complicated and carry weight penalties. High ends and a pronounced line of sheer tend to make a boat easy to right after capsize.

2.2.4 When water is taken on board, the propulsion system must continue to function. In case of a capsize, propulsion must be restored as quickly as possible after the craft is righted. In the case of mechanically-propelled craft, this means that the engine and its air intakes and exhaust must be protected against entry of water. This also avoids expensive damage to the engine. The engine must furthermore be capable of being re-started after stopping for lack of air due to immersion in the sea, and it must not suffer damage if inverted, whether running or stopped.

When setting off from the beach, propulsion must be available immediately the craft is water-borne; the strong current parallel to the beach makes it difficult to pause between launching and setting off, even if the breakers and undertow would permit this. In the case of mechanically propelled craft, the engine should therefore be running before the launching procedure begins. This requirement virtually forces the adoption of an air-cooled engine, with a speed limiting governor. Air cooling also avoids the problems of ingress of sand into the cooling system of sea-water-cooled engines when crossing the surf zone.

2.2.5 Even in a good landing the craft is likely to hit the beach fairly hard, in an attempt to run it up the beach as far as possible out of the way of the breakers. In a less-controlled landing it may strike the bottom before the final beaching; in a capsize it may strike the bottom several times. Any part of the craft may strike, at any angle. The craft must therefore be highly resistant to damage by impact on any of its external surfaces. Protrusions such as fins, bilge keels, skegs, rudders and propellers, bulwarks, rails, and so on, should be avoided, and if unavoidable, they should be retractable, or else fixed with a 'weak link' so that they break free in a collision, without damage.

When negotiating the surf zone and especially when setting out to sea, the craft will be subject to unusually violent accelerations; the hull and all fittings and equipment must be exceptionally stout and well-fastened. In the case of mechanically-propelled craft, the structure supporting the engine, propeller and shaft must be very stiff.

2.2.6 After the craft comes ashore it has to be moved up the beach to a place of safety. It is desirable to do this as soon and as quickly as possible because as long as it remains on the shoreline it is exposed to succeeding breakers and has to be restrained against the actions of the undertow and the sideways current. When setting out to sea, the entire operation has to be done again, in reverse.

It is desirable that these operations can be carried out by the crew of the craft independent of any help from other people on shore, otherwise a higher degree of organization and a more complex organization will be required than has been customary in the fishing communities. Bringing the boat up the beach after landing is a question of steepness of the beach, weight and shape of the boat. On a steep beach, hauling a boat straight up requires considerable man-power. Less effort is needed if the craft has a "rocker" in the bottom and it can be "walked" up the beach by alternately lifting and turning the ends. This is a method of moving heavy beachboats all over the world and is commonly done with the "nava" and the "masula". A straight keel will make it impossible to move the craft in this way and the new beach craft must therefore have a curved bottom profile as seen in vertical longitudinal section on the centreline, and a rounded bottom in transverse section. Mechanical aids, if any, must be simple and cheap. Very simple windlasses or winches, and rollers and planks may be considered. The maximum weight of craft that can be thus handled is about 1000 kg. The crest of the beach makes the effective use of such aids no easier. There is also the problem that the craft must be brought ashore on the limited strip of beach covered by the windlass or winch, unless this is portable.

The alternative strategy, which is the one in use at present, is to manhandle the craft up the beach, using no mechanical aids other than levers and lifting poles; the spars, oars and punting poles of the craft serve these purposes.

For ease of manhandling, the craft should be made as light as possible. Present practice is to remove the catch first, then the fishing gear, and only then to move the craft. In the case of mechanically propelled craft, it would be desirable from this point of view for the engine to be removable.

2.2.7 There is a severe limitation on the weight of a craft that can be manhandled up the beach by its own crew. The kattumaram provides an ingenious way of avoiding this limitation, because it can be split up into smaller components. It is difficult to envisage a practical boat that could be dismantled in this way; twin-hulled and other unorthodox configurations may show more promise.

2.2.8 It has been explained earlier that it is desirable to develop a craft capable of carrying a load of greater volume and weight than the existing kattumarams. That is to say, it requires more usable buoyancy. At the same time, if it is to be manhandled up the beach by its own crew, there is an upper limit to the weight of the heaviest component that has to be moved. It is also desirable, as explained earlier above, that the new improved craft be mechanically propelled. This adds more weight which has to be compensated by more buoyancy.

Generally speaking, the larger the vessel, the more favourable will be the ratio of loaded weight **to empty weight, or in the language of the naval architect the higher** will be the dead weight ratio.

2.2.9 With a limit on maximum weight when empty, the largest carrying capacity will be obtained in the craft with the lightest structure for its size. This requirement is in obvious conflict with the requirement for high strength including high impact strength. This is the fundamental technical problem in designing a surf-crossing beach-landing craft which is small enough to be handled by its own crew, but which can carry a bigger load than a kattumaram.

Only practical trials will reveal whether this is feasible using conventional materials and methods of construction.

It would no doubt be feasible using aerospace materials and technology. This however, would not meet yet another fundamental requirement which is that the capital and other costs should be so related to the likely earnings that the personal income of the individual crew member will be greater than at present. Also, the craft should be capable of being constructed and repaired locally.

It may be that this last requirement, and all the others, cannot be met by any design of craft made of conventional materials which is small enough to be manhandled by its own crew. In that event, the future may lie in beach landing vessels of larger size – improved *navas,* so to speak – with more favourable deadweight ratios and still with adequate strength. These, however, would need mechanical equipment to handle them on the beaches. They would also need larger crews. The whole enterprise would need much more capital and organization. This would mean significant changes in the socio-economic structure of the traditional fishing communities. The lines of development being pursued at present represent an attempt to avoid such changes as far as possible, and to confine any innovations to the field of technology.

2.2.10 It remains to remark that any successful development must meet two other requirements. First, the craft must be acceptable as regards seakindliness and seaworthiness in the open sea outside the surf zone, despite its probably high reserve of transverse stability, high deadweight ratio, and specialised hull form. Second, it must be at least adequate as a fishing platlorm.

3 TRADITIONAL BEACHLANDING CRAFT

3.1 Kattumarams: The most common traditional craft are the kattumarams or log rafts found in Orissa, Andhra Pradesh and Tamil Nadu. Though they show considerable variation in shape, all kattumarams are basically logs tied together. Their main advantages are:

- low initial cost, ranging from Rs. 1,000 to 5,000
- low operation and maintenance costs
- unsinkability
- self-draining ability
- easy to right if capsized
- easy handling on the beach
- sturdy construction.

3.2 Masula: This is a double ended craft 7 to 8 M long used mainly for beach seine operations. The construction is unique in that the planks are stitched together with coir rope and a type of wild grass is used in the joint for water tightness. Due to construction method it is very flexible in a seaway: trips far from the shore are not undertaken in a Masula. This craft is found in Orissa, Andhra Pradesh and Tamil Nadu.

3.3 Nava: This a carvel-planked craft with rounded bottom and unswept ends which make it suitable for beachlanding. The Nava is capable of carrying considerable loads and is used for beach seining and gillnetting. Although the Nava was originally developed for use in the Godavari river delta, its use for surf landing has been on the increase in Orissa and Andhra Pradesh. The shape of the Nava exhibits many desirable features for a surf boat, such as shallow draft and rockered bottom. It is however an open boat and can be swamped by a breaking wave. In this case the hull is usually smashed to pieces against the bottom. With its many thwarts the handling of the gill nets is difticult. Construction such as is utilised in the 'nava' is heavy and requires wide straight planks which might be difficult to obtain considering the size of the logs obtainable on the market. With 25 mm (1") teak planking and heavy framing, a "Nava" of around 10 m length weighs close to 1.5 tons, but with the use of the mast as carrying pole the boat can be moved up the beach by about 20 men lifting and turning the ends.

4 PREVIOUS ATTEMPTS AT DEVELOPMENT

4.1 Surf-crossing beachlanding fishing craft have been developed in other parts of the world, by FAO and by others; FAO can provide further information to those interested.

4.2 An account of previous attempts to develop such a craft for use in India has been prepared for the Bay of Bengal Programme and forms a separate working paper.

4.3 To improve safety in surf crossing, a ropelanding system was tried by FAO in Africa. A rope is permanently fixed between the beach and a buoy moored outside the surf zone. The rope is placed into roller fairleads fixed forward and aft on the boat. The rope can be utilized to haul the boat out through the breakers without engine power since much more force can be achieved by pulling a rope than by rowing or paddling. The rope is also very useful when going in through the surf in that, to a large extent, it prevents broaching. A disadvantage to be considered when placing a rope system is that it can come in the way of other fishermen using kattumarams and can also restrict beach seining operations. Also, if the boat tends to yaw or broach, large forces can be developed which put heavy loads on the fairleads, their fastenings and the structure of the hull. In the extreme case the rope may jump out of a fairlead, or break, and whip across the deck, and may cause injury or damage, or sweep the crew overboard.

5 THE EXPERIMENTAL CRAFT

5.1 General Considerations Governing Design

5.1.1 For the reasons given in 2.2.9 above, it was decided that the new attempt to develop an improved surf-crossing beachlanding craft should begin with the design, construction and trials of craft light enough in weight to be manhandled on the beach by their own crews. These craft would be built in conventional materials and using orthodox methods of construction, although not necessarily materials and methods of construction used by the builders of traditional craft on the east coast of India.

5.1.2 For prototype boats, wood is a very convenient constructional material, since it is cheap and modifications can be made easily. Moreover wood is an obvious choice as constructional material for beachlanding craft, being tough, resistant to shock loading, rigid and light.

For series construction, FRP and aluminium alloy are possible competitors to wood.

5.1.3 It was further decided that the experimental craft would be mechanically propelled, using an air-cooled engine of as light a weight as could be found.

5.1.4 The disposable load, apart from fuel and food, was fixed at four crew, 400 kg. of nets and a catch of 150 kg of fish. A boat with a length of about seven metres should be capable of carrying such a load.

5.1.5 For a boat of 7.0 m LOA, it was considered that this first batch of designs should have beamwidths in the range of 2.25 m to 2.45 m.

5.2 The Prototypes

5.2.1 *IND-10:* See Appendix 1. The 'nava' utilised for beachlanding in Andhra Pradesh is made of teak and officials maintain that fishermen might reject other materials. The IND-10 was designed with a strip-planked bottom to enable the utilization of a smaller-size teak and to increase the strength and improve the watertightness. Unfortunately, the boatyard changed this to seam batten planking which resulted in leak problems, increase of weight and loss of strength.

Large hatches permit access to the storage space for fishing gear. The freeboard of IND-10 is 0.61 m, compared with the 0.43 m of IND-11 and IND-13, otherwise the overall dimensions are much the same.

5.2.2. *IND-11:* See Appendix 2. This craft is based on one of the principles of the kattumaram, namely, the provision of buoyancy by solid members; these are polystyrene blocks totalling 3.5 cubic metres in volume kept in place and protected by a shell of wood. Since the flotation of the craft does not depend on water-tighteness between the planks, low-cost timber can be used, together with simple construction suitable for assembly in the villages.

The need for protecting the buoyancy blocks with some kind of sheathing led to contact with the Indian Institute of Technology to investigate various sheathing methods, and also alternative and cheaper buoyancy materials than polystyrene. This work has not so far produced results that can be put to practical use and the prototype boat was fitted out with unprotected polystyrene blocks. Inspection after the boat had been used for five months from the lagoon of Ennore, near Madras, showed negligible water absorption and relatively clean surfaces. It therefore seems that sheathing of the buoyancy blocks is not essential.

The craft resembles the kattumaram except for an increase in beam and greatly increased carrying capacity. In the same way as the kattumarams, the nets and the catch are placed in bags and lashed onto the deck.

5.2.3 */ND-13:* See Appendix 3. During 1979 polystyrene produced in India increased in cost by 40% and it was decided to build a craft sinailar to IN 0-11 in marine plywood to compare cost, weight and performance. On IND-13 the nets are not stored on deck but beneath large hatches. The hatches can be stored vertically towards the aft bulkhead to leave space for working the nets. During surf-crossing the hatches are lashed down by means of the oars. Compared with IND-11 the bottom shape has been changed by lifting the chine line forward and lowering it aft, with the aim of reducing trim by the stern at full speed.

5.2.4 *IND-14:* See Appendix 4. A twin-hulled craft has normally a greater course-keeping stability than a single-hull craft—an important factor in surf-crossing. Although such configurations are intrinsically heavier than conventional single hulls, they lend themselves to quick dismantling into component parts. The two hulls of IND-14 can be separated from the centre platform by releasing four wedges.

The main features of this craft are:

- Upswept bow with high lift to prevent the bows burying in a following sea.
- Hulls decked forward and aft and with hatch covers midship to permit waves washing over the hull.
- Bridge platform of relatively small size and placed high above the waterline to prevent slamming when surf-crossing.
- Main emphasis on sail propulsion with the use of a 6-8 hp outboard motor for surf-crossing and as auxiliary power.
- Deep hulls to give leeway resistance under sail without the use of centreboards.
- Moderate distance between the hulls to reduce stresses on main cross beams.

5.3 The Nava: See Appendix 5. The Nava offers some prospects for mechanization and development. IND-10 is one approach. Also it was decided to include a typical nava in the test programme as a basis for comparison with the new prototypes. The particulars are given in the following table.

5.4 The Engine Installation

5.4.1 The choice of engine type and horse power are of crucial importance to the economics of operating beachlanding fishing craft, more so than the choice of construction material of the hull. The examples found in developed countries of high powered surf rescue craft or military beachlanding craft have no application on fishing craft on the east coast of India. The engine must be locally produced due to import restrictions. Air cooling was the natural choice since the engine had to be started on shore before launching and to avoid problems with sand suction with a water cooled system. A high power to weight ratio is desirable.

5.4.2 Of the engines available in India, a Greaves Lombardini 523 air-cooled diesel seemed nearest to the requirements. This engine finds its main application in driving small pumping sets. It is rated at 4.8 hp at 3000 rev/mm. Fuel consumption is 1.35 l/hr at maximum power. The price in May 1980 was Rs. 4500 (560 USs).

Less than 5 hp would be considered a very low power for driving a vessel with a displacement of over a ton, especially if the propeller were directly driven at 3000 rev/mm which would give very low propulsive efficiency. No reduction gearbox is available in India for this type of engine, but there is a power takeoff at the camshaft, giving a reduction of 2: 1. This, it was hoped, would give adequate propulsive power for surf crossing. A marine type reverse-reduction gearbox would have cost as much as the engine itself.

5.4.3 To avoid damage when landing on the beach it is essential that the propeller, rudder and skeg do not protrude below the bottom of the boat. A surf craft is often thrown broadside on to the beach, and with propellers and skegs under the boat damage is inevitable. With the engine installed in a pivoting box the whole unit can be quickly retracted by lifting the rudder shaft. The whole unit will also pivot when the heel fitting on the skeg strikes the bottom, a

MAIN PARTICULARS OF CRAFT UTILISED IN BEACH LANDING TRIALS

Craft	Length overall (m)	Beam Maximum (m)	Depth Moulded (m)	Cubic Number LxBxD(m)	Length Waterline (m)	Weight Light (kg)	Weight Loaded (kg)	Powering	Construction
IND-10	7.0	2.45	0.85	14.6	5.5	920	1500	Greaves Lombardine Model LDA5234.8 HPcontinuous/ 3000 RPM Propeller shaft 1500 RPM	Strip planked teak on bottom seambatten sides and deck
IND-11	7.4	2.25	0.72	12.0	5.8	800	1400	Same as IND-10	Polystyrene flotation blocks 19 mm carvel planking
IND-13	7.4	2.25	0.72	12.0	5.8	760	1300	Same IND-10	12mm plywood
IND-14	7.2	2.70	1.0		6.2	600	1100	Outboard motor 8 HP kerosene long shaft	9 mm marine plywood
Nava	9.7	1.85	0.85	15.3	8.0	c.a1300	1800	Oars and sail	25 mm teak carvel planking

very common occurrence when crossing the bar at low tide. The propulsion and steering units of IND-10, IND-11and IND-13 were of this type.

5.4.4 In all these installations, the engine is placed in a watertight box with a removable lid. The lid contains separate ducts for the inlet air and exit for the hot air. The ducts are provided **with baffles and with hinged flaps at the opening to prevent large amounts of water from entering** the box in case of a capsize. In the event of the boat capsizing, sufficient air is trapped in the box, and the intakes are so positioned that water will not enter the engine. The principle is that of the diving bell. The lid must be easily removable but watertight when in place. Water-tightness is achieved by providing a gasket between lid and box and tying the lid tightly to the box with ropes. Toggle clamps may also be suitable but ropes were adopted for the sake of simplicity and to avoid corrosion.

5.5 Rudders: A 'fish' rudder—that is, a rudder the cross-section of which ends in a wide and blunt trailing edge, as would be formed by attaching two vertical bars of triangular section one on each side of the trailing edge of a conventional streamlined rudder, can produce larger steering forces than the conventional. Rudders this design were made for the trials

5.6 Capstan: A simple capstan used during the trials is illustrated in Appendix 6.

6 ORGANISATION OF TRIALS

6.1 Venue: Though the project activity was originally to be located in Andhra Pradesh, it was found more practical to conduct the initial phase of surf trials at Ennore near Madras.

Ennore is a fishing village to the north of Madras city about 20 km away. It makes an ideal test venue for beach trials as it offers access to the open beach on one side and a calm water lagoon on the other. The bar is kept open throughout the year by a floating dredger at the mouth in order to supply cooling water to the electricity generating station nearby.

The fishermen of Ennore are well versed in surf-crossing and landing in their traditional kattu-marams. Moreover, they have been very enterprising and cooperative and were extremely responsive to the idea of testing out new craft on the beach to compare with their traditional craft.

With the cooperation of the Marine Biological Station at Ennore a leading family of fishermen were selected to cooperate in the trials programme. Four fishermen were contracted to work as crew for trying out the various prototypes along with the crew from Andhra Pradesh.

6.2 Construction of Prototypes: Boat building yards for small craft are very few on the east coast of India. Those that exist, build **10** metre shrimp vessels in wood and FRP. It was decided to distribute the construction of prototypes among those yards that were prepared to do so. Three prototypes were built in Madras and one in Kakinada. In addition, one 10 metre Nava was hired from Kakinada.

Most yards are not equipped with any modern woodworking tools and the labour is unfamiliar with the construction of new designs. This resulted in prolonged construction time and the need for constant supervision. Material of the required specification is not readily available leading to rejection, compromise and more delay.

6.3 Timing: Calm water trials, site preparation and testing of the engine and drive unit were held during May and surf trials from the beach were held during June 1980.

One prototype (IND-11) was built in November 1979 and was handed over to the selected Ennore fishermen to use it regularly from the lagoon. This was very useful as it provided basic training to the fishermen on how to use an inboard diesel engine and drive unit. During this time, valuable experience was acquired regarding the engine and its installation.

Surf trials were carried out at Ennore beach during June 1980. The next phase of the trials which is intended to test the suitability of two of the prototypes as fishing craft and also to subject them and the engine installations to continuous service over a substantial period is to be begun in October 1980 at Uppada beach near Kakinada in Andhra Pradesh.

7 PREPARATIONS FOR THE TRIALS

7.1 Successful operation of surf-crossing beachlanding boats requires trained crew. This meant that meaningful trials of the prototypes were impossible until trained crew were available.

7.2 The crew were made up of one 4 man team from Ennore village and ore 6 man team from Kakinada, in addition to the surf boat expert. A combination of the crews was also used on several occasions.

7.3 Still water training was carried out at Ennore creek. The purpose was to instil confidence in the boats among the crew and to demonstrate the importance of a coordinated team effort when working on the surf beach and in the surf. Failure to achieve this would probably result in personal injury or damage to equipment.

In particular, the crew were trained in the following:

1. The positions to take up to hold the craft ready, prior to pushing off the beach.
2. Coordinated pushing of the craft into the water.
3. To keep the craft running forward till crew is ordered on board by the leader.
4. To jump aboard without delay to predetermined positions.
5. Coordinate use of punting poles before lowering the propeller.
6. To move forward or aft to alter the weight distribution in the surf zone.
7. To disembark on landing and push the craft up the beach.

Instructions were also given to the crew on daily checks required on the engine unit and on the starting and stopping of the engine. Instructions were also given to selected helmsmen on operating the pivoting drive unit and correct throttle setting.

7.4 Technique

7.4.1 *Going Out.* The correct techniques are as follows:

1. Approach all waves head on.
2. Use correct timing to approach the oncoming surf so that the craft is not put under a plunging wave.
3. Do not power the craft over a wave peak to avoid being airborne and losing balance.

7.4.2 *Coming In:*

1. Use correct timing to enter the surf zone to avoid exposure to large waves.
2. Time the run so that the craft is not positioned under a plunging wave as it breaks.
3. Keep a steady course by correctly aligning the craft.
4. Keep the crew and equipment properly distributed.