BAY OF BENGAL PROGRAMME
DEVELOPMENT OF SMALL-SCALE FISHERIES

MOTORIZATION OF DINGHY BOATS IN KASAFAL, ORISSA

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This paper describes an attempt to motorize traditional fishing boats (dinghies) commonly used in Balasore district, Orissa, India. Several technical problems were encountered and three different modes of power transmission were tested. The motorized dinghies were employed in commercial fishing operations and their performance was compared with that of non-motorized dinghies.

The work was sponsored by NORAD (the Norwegian Agency for International Development) under an Indo-Norwegian bilateral project for assistance to traditional fisheries in Kasafal, Balasore district, and implemented through the Directorate of Fisheries in Orissa. Mr. B.B. Mohapatra, Dy. Director of Fisheries, Balasore, was responsible for the Directorate's input.

The small-scale fisheries project of the Bay of Bengal Programme (BOBP) was engaged by NORAD for technical execution of the project. Mr. A. Overa, BOBP's Fishing Craft Engineer, was responsible for the technical inputs till mid-1985; thereafter Mr. 0. Gulbrandsen, Naval Architect (Consultant), and Mr. S. Johansen, BOBP Naval Architect (Associate Professional Officer), supervised the modification of hulls and installation of engines, prepared drawings, and in general looked after technical details.

The BOBP's small-scale fisheries project began in 1979 and covers five countries bordering the Bay of Bengal — Bangladesh, India, Malaysia, Sri Lanka and Thailand. Funded by SIDA (Swedish International Development Authority) and executed by the FAO (Food and Agriculture Organization of the United Nations), the project seeks to develop, demonstrate and promote appropriate technologies and methodologies to improve the conditions of small-scale fisherfolk in member countries.

CONTENTS

1. BACKGROUND

1.1 The "Gram Panchayat" of Kasafal in Balasore district, Orissa, recently started receiving assistance to develop its traditional fishery under the Indo-Norwegian Development Cooperation Programme. The largest component of the project is construction of a 22 km road. Other inputs identified are provision of drinking water and electricity; establishing non-formal primary schools; provision of preservation, storage and marketing facilities for fish; and motorization of traditional fishing boats (the subject of this report). The agencies responsible for execution of the project are the Norwegian Agency for International Development (NORAD) and the Orissa Directorate of Fisheries (DOF).

1.2 Experimental fishing with a motorized gillnetter based at Chandipur, which is located only 6 km from Kasafal, was undertaken in 1980/81 under the direction of the Norwegian Research Institute for Fishing Technology (FTFI). From the trials it was concluded that there are no signs of overfishing of the stock in spite of a rapid increase in the number of motorized boats. By increasing the radius of operation of the boats, extending the fishing season and improving fishing gear, the landed catch could be considerably increased.

1.3 The fishing fleet of Kasafal consists of some 350 boats. There are 75 motorized gillnetters, IO-1 2 m long, usually fitted with second hand truck engines of around 60 hp. In terms of investment they are outside the reach of the traditional fishermen. There are also about 50 small dinghies (known locally as *Paukia)* and 50 boats of other types (Salti, *Patia, Choat)* which are not very suitable for motorization. The largest number of boats (175) are large dinghies (known locally as *Danga).*

1.4 Typical dimensions of the Dinghy are : 7-9 m length, 1.8-2.1 m breadth and 0.9-1.0 m depth. It has a crew of five to seven and it is sailed or rowed (see Fig. 1). It lends itself fairly easily to motorization with an inboard diesel engine.

1.5 In order to clarify technical questions regarding installation and operation of the engine and to compare the merits of motorized and non-motorized dinghies, BOBP was requested to assist NORAD and DOF in implementing a pilot project to this effect. Four boats of the dinghy type would be motorized, and operational data would be collected over a full year. The work started in June 1984. A sequence of events is given in Appendix 1.

2. ENGINE INSTALLATION

2.1 The dinghy has an estimated weight of about 1.0 tonne (t). With a crew of five and fishing nets, the displacement is approximately 1.5 t. An engine of 8-9 horsepower (hp) maximum rating would be suitable for this displacement. It is then assumed that the engine would normally be operated at a reduced service power of about 5 hp. BOBP had previously been involved with the marinization of an 8 hp aircooled tiller tractor engine for use in beachlanding craft (BOBP/WP/44) and it was natural to utilize this experience in Balasore. This is not the only engine that might be suitable for use in the dinghies, but BOBP considered it unwise in the initial period to experiment with different types of engines. This would have to be considered as a second stage after proving the general viability of motorization.

2.2 The engine is a single cylinder VST Shakti type AD-8, aircooled, with a maximum rated output of 8 hp at 3000 r.p.m. Continuous DIN A rating is 7.2 hp at 3000 r.p.m. Optimum fuel consumption is at 5.6 hp output and 2500-2600 r.p.m. As the power take-off is from the camshaft the reduction ratio is 2: 1. At service speed the propeller therefore turns at 1300 r.p.m. The engine is primarily used in a tiller tractor and is manufactured by VST Tiller Tractors Ltd. in

Bangalore in cooperation with Mitsubishi Heavy Industries, Japan. For marine use the following changes have been made to the standard engine.

(i) A taper roller thrust bearing was provided at the output shaft end (camshaft) instead of a ball bearing.

(ii) The standard camshaft was changed to one with a taper to enable fitment of a flange coupling.

(iii) A raised pipe was provided for easier oil filling and access to the dipstick.

(iv) A single lever stop and throttle control was provided.

Sterngear was of the conventional type with a water lubricated sternbearing and a grease lubricated stuffing box.

2.3 In June 1984 BOBP staff visited Balasore to check the possibility of installing a VST 8 hp aircooled engine on the dinghy. It was decided to install the engine without a clutch, as has been the practice elsewhere in India when motorizing traditional craft with this engine.

To minimize shaft length and thereby the cost of the sterngear, the engine had to be installed as far aft as possible. This meant that the nets had to be stored further forward (see Fig. 2a). Fishermen operating dinghies concurred with the idea, perhaps due to the fact that in larger motorized boats in the area, the nets were indeed stored forward of the engine. No problems were foreseen in the shooting or hauling in of nets. However, the new position of nets in the boat interfered with the stepping of the mast in its original place. This was not considered serious as a new rig could be developed if motorization proved successful. The first dinghy (BOBP No.1) was motorized in December 1984. Preparations to motorize the other three were also under way.

2.4 After only a few days of operation the fishermen complained of two problems; running over surface drift nets and lack of speed. While the former problem was not foreseen, the latter appeared to be due only to the high expectations of the fishermen. Speed trials with two propellers were undertaken in February 1985 (see Appendix 2). A speed of 6 kn was achieved with a 14 in x 8 in propeller at 2600 r.p.m. It dropped to 5.4 kn at 2300 r.p.m. but the fuel consumption improved from 0.37 to 0.25 l/n mile. It is unlikely that the fishermen would heed the advice of operating at a lower speed. To improve propulsion efficiency (more speed at lesser fuel consumption) and solve the problem of cutting nets (unfortunately the magnitude of the problem was not assessed), it was decided to try out a reverse reduction gear box with a clutch. The same engine manufacturer was in the process of developing such a unit. One could argue that a clutch was sufficient but the possibility of achieving a higher speed and better propulsive efficiency with a larger diameter propeller was an equally important consideration.

2.5 The original design of the keel did not allow the use of a propeller of 18 in diameter which would be the optimum size with a 2: 1 reduction gearbox. It was therefore decided to move the shaft log further aft and higher up (see Fig. 2b). At the same time the additional draft caused by adding a wooden keel for propeller protection was reduced. A flat steel shoe was made to replace the wooden piece under the propeller to reduce draft as much as possible. The three dinghies with the VST engine and gearbox (BOBP No. 2, 3 and 4) were ready for fishing trials in August 1985.

2.6 After the four motorized dinghies were operated for some time, it became clear that they suffered from alignment problems. After the engine had been carefully aligned with the propeller shaft it did not take many weeks before the engines came out of alignment due to vibration and weak boat construction. This resulted in a severe problem of broken foundation bolts; on one dinghy, even the propeller shaft broke near the coupling. Many fishing days were lost due to this problem. It was then decided to utilize a double universal joint and a thrust bearing between the propeller shaft and the engine. The extra thrust bearing is required to prevent buckling of the flexible intermediate shaft. This method would have the following advantages.

(a) No alignment problem; the fisherman can himself remove the engine and reinstall it without the help of an experienced mechanic.

(b) The nets can be carried aft in the traditional way and the mast can stay in its normal position for sailing.

(c) The boat would be better balanced and it would minimize the risk of broaching in a following sea.

(d) An ice box can be fitted in front of the engine.

2.7 The BOBP No. 2 was converted in this way in April 1986 (see Fig. 2c). Trials showed that this dinghy could be sailed without difficulty, using the rudder for steering. Setting and hauling the net over the stern did not cause any particular problems.

The fisherman however decided later that he preferred to have the nets forward and to cover the aft position of the dinghy to afford better shelter for the crew, as in the case of larger motorized gillnetters.

On the basis of the positive experience with the new installation, it was decided to convert the other three dinghies. Two of them were converted by late July 1986. The fourth dinghy is scheduled for refit in September 1986 at the request of the fisherman operating it.

2.8 In December 1985 the Indian manufacturers of Lombardini engines, Greaves Cotton, motorized one dinghy with their model LDA 510 aircooled diesel developing maximum 10 hp at 3000 r.p.m. (DIN B rating). The engine was fitted with a 2.47 : 1 reverse reduction gearbox.

Motorization was carried out in cooperation with the Directorate of Fisheries in Balasore. The manufacturer supplied the Lombardini engine and stern gear. The keel of this dinghy was done in the same way as on the dinghy motorized by BOBP. However, the engine is placed aft with a single universal joint and no thrust bearing though it is not good engineering practice to install one universal joint. The installation was completed in December 1985. Till July 1986 the Lombardini-fitted dinghy had operated for 76 days compared to an average of 32 days for the boats motorized with the VST engine. No major problems were reported except for replacement of oilseals and piston rings during this period. Perhaps this was due to the use of a smaller diameter propeller (15 in v/s 18 in) compared to the one on the VST engine which has resulted in lighter loading of the engine. The choice between these two engines and systems will in the future depend upon performance, price and easy availability of spares and service facilities.

It must be noted that the Lombardini 510 engine must be fitted with a reduction gearbox due to its high output r.p.m. (3000) as compared to the VST AD-8 engine.

3. FISHING TRIALS

3.1 The Directorate of Fisheries in Orissa was responsible for monitoring the fishing trials. Data collection was organized by a fisheries extension officer based at Channuwa village on the road to the landing site. For each trip the fisherman noted the data concerned which were later compiled by the Fisheries Extension Officer. A sample data form is shown in Appendix 3. Data were collected from May 1985.

The motorized dinghies were compared with the same number of non-motorized dinghies operating approximately the same type and quantity of fishing gear.

3.2 The gear carried by the dinghies was surface driftnets, mainly of the Phasi Jalo or Hilsa Jalo type. The netting material was polyethylene multifilament, the mesh size varied between 75 and 114 mm. The depth varied between 110 and 200 meshes. Total hung length of the nets carried per boat averaged 1,100 m. Both motorized and non-motorized dinghies carried the same length of net. The total cost of the fishing gear was about Rs. 20,000. At this stage no increase in fishing gear quantity was contemplated for the motorized boat as the idea was to compare both types with the same quantity of gear.

Another reason for not carrying more nets was the fishermen's apprehension about possible loss of nets due to theft or trawlers and larger gillnetters running into the nets.

The nets are set in the evening and retrieved the next morning. Occasionally day fishing is done at times of high abundance. The nets are usually set and hauled over the stern.

3.3 As the motorized dinghies are able to explore grounds further offshore, perhaps making longer trips in the process, provision of an ice box to preserve quality fish was considered for trial. An icebox of 0.36 m^3 (360 l) capacity was made by a local FRP Company--Reinplast ***Marine.*** The box was made of 6 mm FRP sheathed plywood and insulated with 75 mm polystyrene. The capacity of this box is about 100 kg of fish and two ice blocks of 50 kg. This size was considered adequate as fishing trials indicated an average catch of 40 kg/trip. The icebox was fitted to boat No. 2 with the engine in the centre, nets aft and icebox forward.

The fisherman, however, removed the icebox later. The reason given was that the fishing was close to Kasafal during this time of the year; therefore there was no need for an icebox. The same fisherman also rearranged his dinghy. He put the nets forward and made a decked crew shelter aft, which did not leave any space for an icebox in the future. It remains to be seen what the three other boat owners will do once the fishing season commences late August.

3.4 Usually five men go fishing in a dinghy. The motorized dinghies too had the same number of crew.

The crew share system at Kasafal is an interesting one. It is very rare for one individual to own the boat as well as the nets. Usually, half the number of nets is made up of individual contributions from the crew and the other half is supplied by the boat owner. The crew member is entitled only to the fish caught in his portion of the net which is clearly marked.

In the non-motorized dinghies the only contribution from the crew to the boat owner is to help him in hauling his portion of nets and in operating the boat.

In the case of the larger motorized gill netters, a crew of up to ten fishermen contribute nets and they have to give half of their catch to the boat owner for the privilege of going on a motorized boat to better and distant grounds in addition to paying half the running costs. There are a few cases also of the boat owner owning all the nets. In such a case he usually hires fishermen for a monthly wage of Rs. 300. In addition he awards them a year-end bonus, usually in kind, in the form of clothes or some personal accessory like a radio or a watch.

It is clear that the boat owner stands to gain with motorization. Crew with nets will also benefit as their contribution to the boat owner may be offset by better catches with a motorized boat. The fate of the fisherman who possesses neither boat nor nets will remain the same. He will continue to be paid a monthly wage in return for hard labour. At the most he may earn a higher bonus at the end of the year.

4. ANALYSIS OF DATA

4.1 The data on fishing operations was collected over a period of 12 months, from May 1985 to April 1986. For the first four months, however, data was collected only from one motorized dinghy (BOBP No. 1) and one non-motorized dinghy (CC). See Appendix 4. Average figures of the performance data for BOBP No. 1,2,3, and 4 and CC No. 1,2,3, and 4 over the 8-month period (September 1985 to April 1986) are given below :

	Motorized dinghy	Non-motorized dinghy
Average gross revenue (Rs.)	16,300	16,400
Range of revenue (Rs.)	8,000-25,000	5,000-25,000
Average number of trips	59	112
Range	30-79	60-I 47
Average gross revenue per trip (Rs.)	276	146
Range of revenue (Rs.)	200-350	90-I 83
Average cost per trip (Rs.)	62	9
Average net revenue per trip	214	137
Range of revenue (Rs.)	140-288	81-174

- There is a great variation in performance between different dinghies probably because crew skills vary.
- The gross revenue over the period is the same for motorized and non-motorized dinghies.
- The number of fishing trips is much lower for the motorized dinghies.
- The gross revenue per trip has almost doubled for the motorized dinghies.
- Net revenue per trip is 56% higher for the motorized dinghies.

4.2 The potential shown for increased earnings by the motorized dinghies by almost doubling the gross revenue per trip has been clearly demonstrated. The gross and net incomes during the trial period are shown in Fig. 3. However, the motorized boats were out of commission 42 per cent of the time on an average due to engine defects (see p. 6).

Loss of fishing days over an 8-month period, September-April. (Average for BOBP I-4 and cc I-4).

	Motorized Dinghies	Non-motorized Dinghies
1. Engine repair	104*	1
2. Hull repair	8	12
3. Rough sea	9	10
4. Rain	7	15
5. Full moon	6	8
6. Poor catch expectancy	6	10
7. Net repair	21	39**
8. Holidays	5	11
9. Crew rest	1	1
IO. Crew problem	18	24
Total days lost	185	132
Average No. of trips	59	112
Total No. of days for eight months	244	244

Unless the mechanical problems can be solved, the motorized dinghies will clearly not be viable.

4.3 In the beginning, the main reason for engine trouble was the alignment problem. This problem has been solved with the new installation using a double universal joint and a thrust bearing. The second main problem, with the gear box, has however not yet been solved. Before the reliability of the gear box is proven, it should not be fitted on dinghies.

4.4. Even in the future, loss of fishing days due to mechanical problems cannot be completely eliminated. During the fair weather season (September-April) the non-motorized dinghies averaged 14 trips per month. During the monsoon months (May – August), the average drops considerably. Even if we assume the same average during the monsoon months, the total number of trips per year is only 168 for the non-motorized boats. It is not very clear whether this low Figure is partly due to time spent on agriculture. For motorized dinghies one would have to assume an even lower number of fishing days due to mechanical problems. Even if the fishermen could go fishing under sail, with the propeller removed in case of engine breakdown, it is doubtful whether they would do so. The reluctance to return to sail has been the bane of many a motorization project. One can only assume that longer exposure to motorization will lead to better engine maintenance with less 'downtime' and better utilization of the increased range of boat.

4.5 On the basis of the recorded data on revenue per trip, the rate of return of a non-motorized dinghy is 19 per cent while that of a motorized (without gear box) dinghy is 19.3 per cent. The details are given in Table 1.

The extra investment of about Rs. 6,000 required for a gearbox would increase the yearly fixed costs by about Rs. 1,200. However the gearbox would improve the fuel economy considerably if the engine was operated at about 2,600 r.p.m. (see Appendix 2). The variable costs would therefore be reduced by about Rs. 2,000 and the rate of return would be about the same as without gearbox. These differences are of academic interest only; it is the earning capacity, still unknown, that is the determining factor.

The comparison is based on a uniform crew salary of Rs. 2,520 (168 x 15) which appears to be the opportunity cost in the area. This would correspond to a crew share of 51 per cent for the non-motorized and 37 per cent for the motorized boat based on net revenue (gross revenue-fuel costs).

*BOBP-3 capsized and went out of commission for two months.
**CC-2 lost nets and stopped fishing for two months.

4.6 With the share system as described in 3.4, the return on investment for the non-motorized dinghy owner who owns half the quantity of nets would amount to 26 per cent, while the return on investment on the crew's gear would be only three per cent. This rate is calculated after deducting from the respective shares, a salary component of Rs. 2,520 per man. If the same share system was applied to the motorized dinghy, the boatowner's return would only be 13 per cent against 49 per cent for the crew.

If the share system as used in the larger motorized gillnetters is used for a motorized dinghy, the return for a boat owner would increase to 36 per cent while the crew would suffer a loss of 54 per cent.

Table 1

Costs and Earnings

Rs

	Non-motorized dinghy	Motorized dinghy
I. Earnings		
No. of trips per year	168	150
Gross revenue per trip	147	277
(a) Annual gross revenue	24,700	41,550
II. Investment		
(a) Hull	12,000	12,000
(b) Hull modifications		5,000
(c) Engine without gearbox		10,500
(d) Gearbox	–	
(e) Sterngear, propeller		5,000
(f) Thrust bearing		1,000
(g) Universal joint		800
(h) Sail rig	600	600
(i) Sub-total	12,600	34,900
(j) Fishing gear	20,000	20,000
Total Investment	32,600	54,900
III. Annual Fixed Cost:		
(a) Depreciation of hull (10 yrs)	1,200	1,700
(b) Depreciation of Sail Rig (3 yrs)	200	200
(c) Depreciation of Engine and Equipment (5 yrs)		3,460
Total fixed cost	1,400	5,360
IV. Annual Variable Cost:		
(a) Fuel and oil (11 l/trip at 4.5 Rs/l)		7,500
(b) Engine repair		1,000
(c) Hull repair	500	500
(d) Gear repair and replacement (20% of j)	4,000	4,000
(e) Crew salary (5 x 2520)	12,600	12,600
Total variable cost	17,100	25,600
V. Total annual cost (III+IV)	18,500	30,960
VI. Net return (I-V)	6,200	10,590
Rate of return VI/II x 100 (%)	19.0	19.3

5. FUTURE DEVELOPMENT

5.1 The results of fishing operations conducted with motorized dinghies are not fully conclusive, but indicate that motorization of this type of craft is economically viable. The fishing operations, including the quantity of nets used, have been very similar to those carried out by non-motorized dinghies. If the potential of the motorized dinghy-its capacity, range of operation, versatility of gear, etc. — is tapped better, a much better performance than that seen during the first year's trial is anticipated.

5.2 One of the technically feasible solutions regarding engine installation available after the trials is the VST 8 hp engine without gear box, with double universal joint and thrust bearing and a 13 x 8 in propeller. The disadvantage of this solution is that the propeller cannot be disengaged when the boat accidentally runs into driftnets. There are conflicting views as to the gravity of this problem.

5.3 If the fishermen do not consider the cutting and entangling of nets a crucial problem, it is suggested that a small number of engines (say about 20) be introduced. Some of the teething problems with engine maintenance and service will no doubt continue and will affect the operations to a certain extent. An initial subsidy for the engines may therefore be justified.

5.4 Any order for a batch of engines should be conditional on a guarantee from the manufacturer to provide the necessary spares and services wherever the engines operate.

5.5 The question as to what extent fishermen will benefit from motorization depends on the share system that is adopted. If the traditional share system -in which the crew owns the nets -continues, a definite benefit will accrue because the catch per net will double. But the traditional distribution of shares needs to be adjusted because of the additional costs of motorization. If the system as practised on some of the larger motorized gillnetters is adopted (i.e. the crew receive food and a daily wage from the boat and net owner), the crew members will enjoy no particular advantage. For engines issued with subsidy and/or credit, it might be appropriate to stipulate a system that assures fair shares to the owner(s) and the crew.

5.6 An installation with a gearbox might in the long run offer a somewhat better solution. The investment cost will go up but it will probably be fully compensated by better fuel economy. The technical problem encountered with the VST gearbox is clutch slippage-something the manufacturer has not yet solved. The three engines fitted with gear boxes should not be transferred to the fishermen until a satisfactory solution to this problem has been found. The trial period should be extended for at least another six months. Close cooperation from the gearbox manufacturer is required.

5.7 A solution with gearbox offers more engine alternatives than the 8 hp VST. The 10 hp Lombardini is one, already being tested in the project area. Close observations of the performance of this installation should be made as for the three VST installations during the extended trial period.

5.8 To reduce the cutting of nets by the propeller a clutch could be used to engage and disengage the propeller in an installation without gearbox. This would however increase the investment cost and there would be no improvement in fuel economy to compensate for it. The clutch alternative would therefore be the last one and be attractive only if the gearbox solution fails.

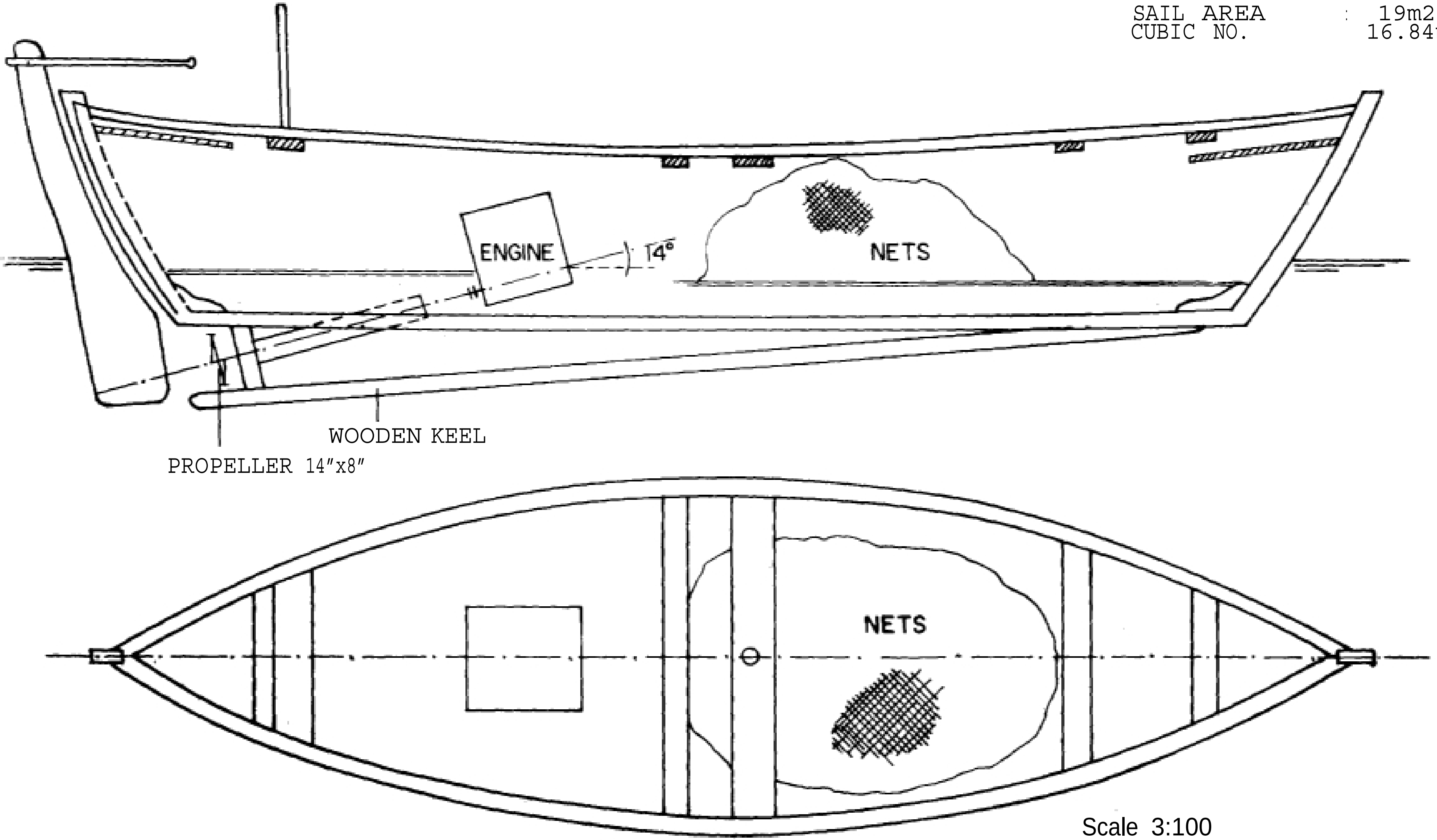
Figure 1

Traditional dinghy being rowed (above) and under sail (below).

Figure 2a
MODES OF POWER TRANSMISSION
Direct drive

MAIN DIMENSIONS

LENGTH OVERALL:	8Om
BEAM MOULDED :	2 l m
DEPTH TORAIL	1.0m
SAIL AREA :	19m2
CUBIC NO.	16.84m3



Scale 3:100

Figure 2b: Modes of power transmission—Gear box

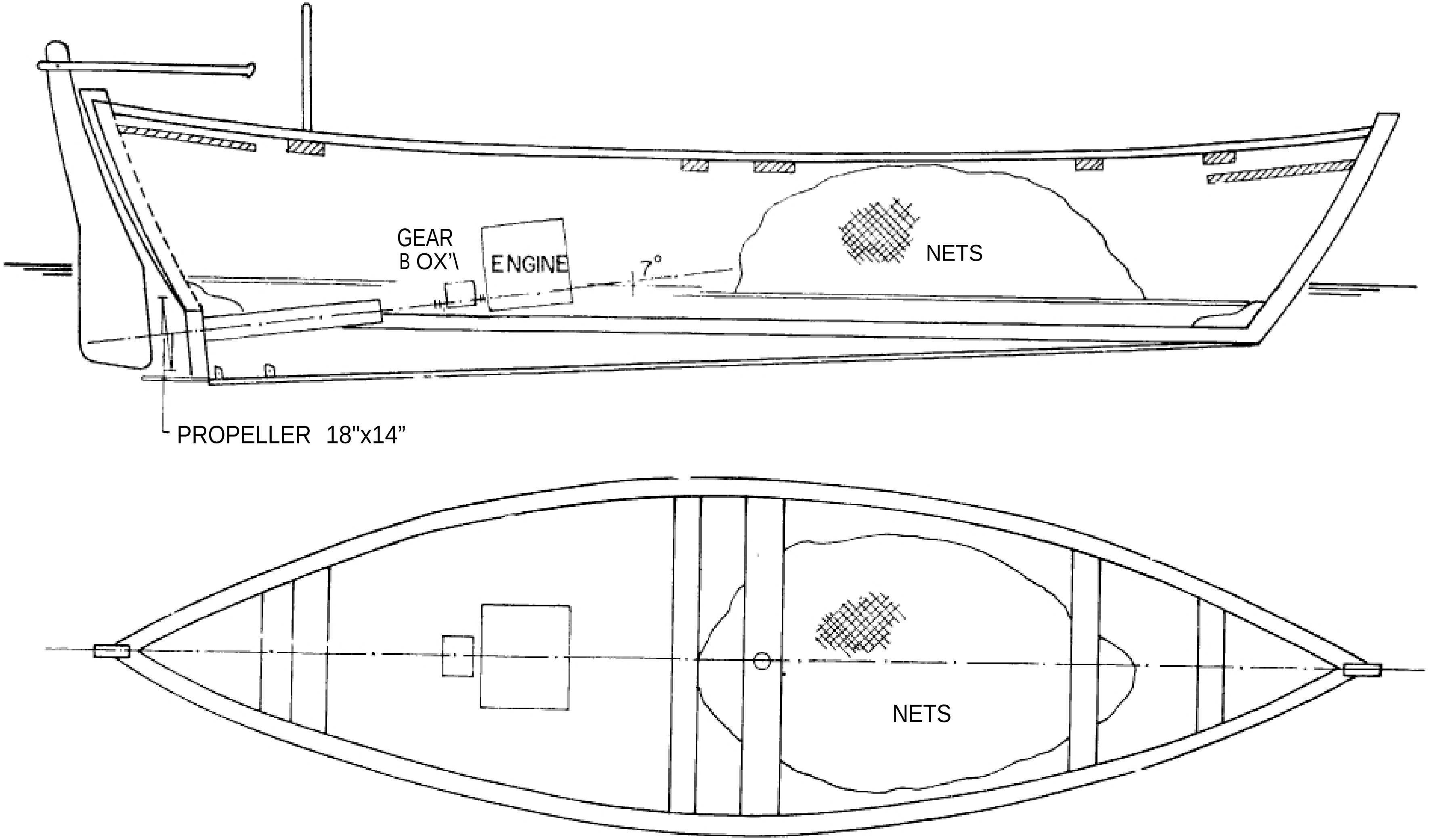


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Figure 2c Modes of power transmission---Gear box, double universal joint and thrust bearing

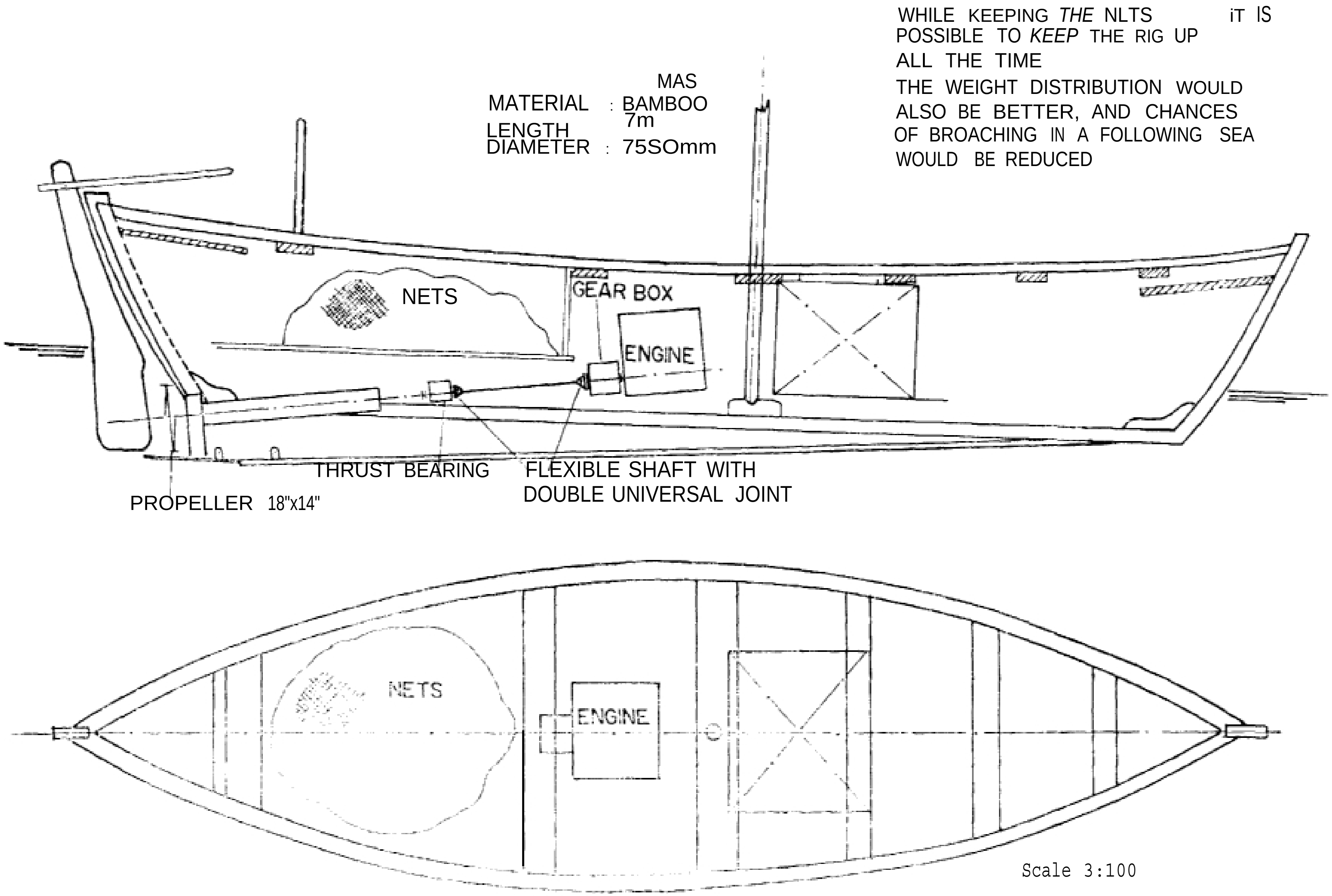

Figure 3
GROSS AND NET INCOME PER TRIP FOR MOTORIZED AND NON-MOTORIZED DINGHIES