Technical Survey of Traditional Small Fishing Vessels

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Etude technique des petits bateaux de pêche traditionnels

Etude technique détaillée des petits bateaux de pêche japonais utilisés sur tout le littoral, s'attachant particulièrement à leur bonne tenue à la mer et à la simplicité de leur construction. L'emploi de sections polygonales et de bouchains vifs, outre qu'il simplifie la construction et réduit les travaux d'entretien à terre, augmente parfois aussi le rendement des opérations de pêche.

Análisis técnico de las pequeñas embarcaciones pesqueras cionales

Son técnicamente estudiadas en sus detalles las pequeñas em ciones que más se ven en todas las costas japonesas, especial en lo que se refiere a sus favorables condiciones marine sencilla construcción. Sus secciones poligonales y la robustez doble arista no sólo simplifican la construcción y reduc manutención en tierra, sino que a veces favorecen las opera de la pesca.

MODEL resistance and structural testing of traditional Japanese small fishing vessels were presented at the Second FAO World Fishing Boat Congress; now, investigations are introduced concerning the sea-keeping performance in waves and methods of construction. In the distant past the empirical design provided safety and easy maintenance which was essential to the fishermen, and they could reach the coast of China crossing 500 miles of the East China Sea. Their practicability is proved because, even today, nearly 400,000 fishing vessels smaller than 20 GT are, without exception, of the Japanese traditional type (fig 1). Low building and maintenance costs are advantages of this type of fishing vessel, and therefore such a design may be a good guide to those intending to set up small coastal fisheries with limited capital in developing countries.

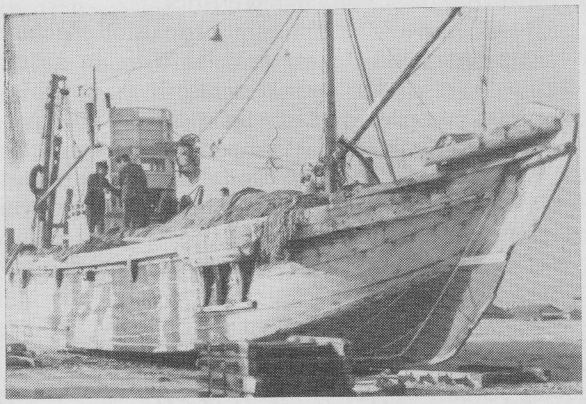

Fig 1. Traditional type Japanese fishing vessel

Beach landing can be easily performed with assistance of housewives from neighbouring families even for craft up to 50 ft (15.3 m). Boats of 30 ft (9.2 m) may be handled alone by the aged or a married couple. Nowadays, outboard motors or small diesel engines are utilized also the beach landing winch, formerly ma operated, has been mechanized by drum and small m The device for lifting the propeller and rudder and wide flat bottom of the keel keep the boat stable being slid on either sandy or pebble beaches. Wo slats are sometimes used as a slipway for heavier b larger than 30 ft (9.2 m) on soft sandy beaches (fig 2

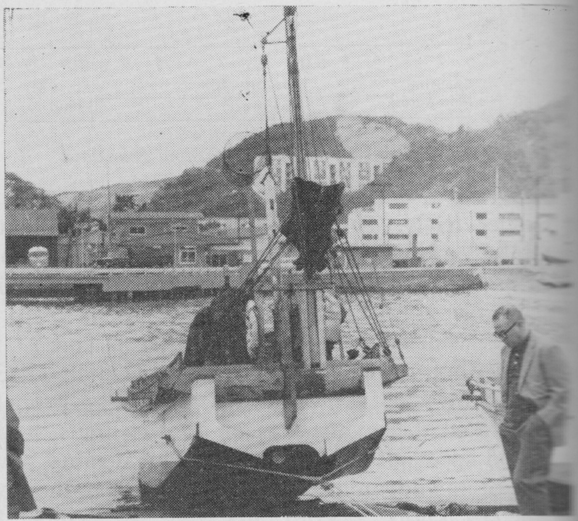

Fig 2. Stern detail of Japanese fishing vessel

Although the angular shape of the hull might ap to give bad sea-keeping properties the empirical d methods have reasonably avoided the dangerous nant conditions better than the conventional ro bilge type when subjected to tests in waves. The lo tudinal distribution of section shape and area co the value of the longitudinal GM and the inertia efficient, including the entrained water mass, and gi moderate longitudinal motion with the encountering wave, even in the worst synchronized conditions at low speeds. The angular shape of the hull and the deep rudder tend to damp the motion in waves, and is one of the most important factors in producing favourable seakindliness.

The same is true of the safety margin in the synchronous rolling conditions, and it is possible to maintain an ample righting potential in specific weather conditions by good design. The hard chine tends to damp the roll in resonant conditions and, because of the small transverse GM, there is little possibility of resonance in short-crested waves just off-shore.

The reserve of buoyancy should be obtained by providing sufficient freeboard to overcome the worst conditions.

The long and narrow rudder compensates for the low lateral resistance of the shallow keel, thus reducing the tendency to transverse drift in cross seas and wind.

According to statistics, a large proportion of sea casualties are caused by incorrect steering and misuse of engines. The safety margin should be high for all circumstances and engine reliability is very important.

The various properties of good ship performance mentioned above can be obtained comparatively easily for round-bilge European vessels. But special care and sound experience are required to obtain these properties and approach the ideal of good performance for the traditional Japanese type of boat.

In the design, certain longitudinal and transverse members are deleted. This saves labour during construction but, as all loads must be carried by the shell plating, good techniques are required for constructing the hull skin. Many types of soft wood may be used, according to availability; and with good maintenance, especially of the seams of shell plates and bottom knees, an average boat's life should exceed 20 years.

The price obviously varies according to cost of materials and labour. Recently, the local labour cost variation has become small, but material costs vary immensely depending on the type and quality of the wood, and it has become difficult to obtain timber of large dimensions with natural curvature. The hull prices, from statistical data of 1963, Ministry of Agriculture and Forestry, are shown in table 1.

The total number of fishing boats less than 20 GT in 1963 was 391,545, of which only 179,409 were mechanized. The mean tonnage of the unpowered boat was 0.81 GT and that of the powered 1.79 GT. The mean engine power was 7.88 hp. The general trend between 1953 and 1963 may be seen from fig 3, which shows an increase in powered vessels of 64 per cent and a decrease in unpowered of 32 per cent.

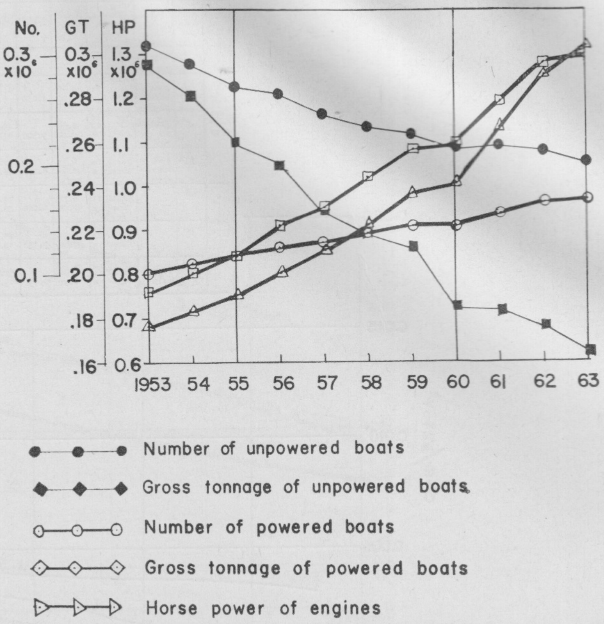

Fig 3. Statistical data of Japanese fishing boats under 20 GT

RESISTANCE AND PROPULSIVE CHARACTERISTICS

Resistance characteristics

The Japanese traditional chine boat can be designed to give the same resistance characteristics in calm water as European round-bilged vessels. Some test results of three Japanese and three European boats are compared in fig 4; the frictional resistance was derived from the Schoenherr line. The small Japanese traditional boat M-7, 26 ft (7.9 m) for general fishing, has excellent results up to Froude Number, Fn = 0.40 (6.4 knots), whereas the M-8, 36 ft (11.0 m) pole-fishing boat is good up to Fn = 0.35 (6.3 knots).

M-57, 52 ft (15.9 m) purse seiner (fig 2) has a higher resistance over its entire speed range, even below Fn=0.30 (6.8 knots). The fish hold occupies a large part of the boat and the low and flat bottom is necessary for daily launching at surf side.

M-11, 72 ft (22.0 m) trawler, and M-13, 61 ft (18.7 m) purse seiner, have a round and full hull form and their practical speed should be lower than Fn=0.30 (about 8 knots). M-61, 47 ft (14.35 m) trawler, has fine lines (Cp=0.582) and shows an excellent performance over all the speed range.

TABLE 1. **Cost of hull of traditional Japanese fishing vessels**

	3 *GT*	5 *GT*	10 *GT*	20 *GT*
Quality of Materials	£ ($)	£ ($)	£ ($)	£ ($)
High	480 (1,340)	875 (2,450)	1,750 (4,900)	4,100 (11,500)
Low	275 (770)	500 (1,400)	1,150 (3,220)	2,500 (7,000)

Note: Hard wood—*Quercus glandulifera*, zelkova, camphor
Medium —Cherry, Japanese cedar
Soft wood —Pine, Japanese Judas
GT —0.55 LBD in metric unit (19.4 LBD in ft unit)
The hull price includes the complete vessel and gear, except for the electrical equipment.

Type of Ship	Model No.	Name of Ship	Kind of Ship	Model Length l_{pp}	=Lpp/l_{pp}	Lpp	Iwl	B	T_m	Δ	C_b for Lwl	C_p for Lwl	$C_{\otimes}$	Lwl/B	B/T	∇/(Lwl/10)^3	S
Japanese Type	7	Jinsui-maru	Experimental Boat ft m	6.56 2.00	4.050	26.60 8.10	24.00 7.30	6.75 2.06	1.31 0.40	2.37	0.461	0.589	0.783	3.54	6.63	5.95	147.90 13.75
	8	Akatsuki	Experimental Boat ft m	6.56 2.00	5.500	36.20 11.00	36.00 10.98	7.41 2.26	1.94 0.59	7.00	0.534	0.668	0.799	4.86	4.64	5.16	265.50 24.69
	57	No.2 Sakai-maru	Purse Seiner ft m	6.34 1.93	8.276	52.50 16.00	51.30 15.62	13.45 4.10	3.22 0.98	37.33	0.688	0.710	0.969	3.81	5.19	9.54	819.00 76.10
Round Type	11		Small Trawler ft m	6.56 2.00	11.000	72.20 22.00	74.50 22.73	15.15 4.62	7.85 2.39	130.00	0.572	0.647	0.884	4.92	2.21	10.80	1650.00 153.23
	13		Purse Seiner ft m	6.56 2.00	9.350	61.40 18.70	60.00 18.33	15.65 4.77	5.18 1.58	81.00	0.636	0.681	0.934	3.84	3.41	12.83	1165.00 108.21
	61	Nigata-maru	Small Trawler ft m	5.00 1.52	10.050	50.20 15.32	50.00 15.16	12.40 3.78	4.14 1.26	31.53	0.477	0.582	0.820	4.01	3.40	8.86	692.00 64.40

Keel excluded, rudder included

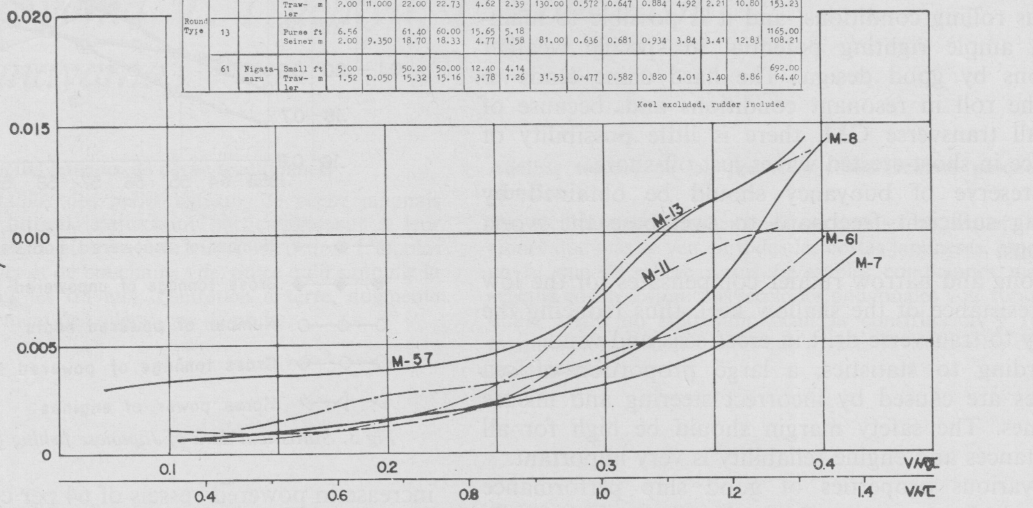

Fig 4. Comparison of residual resistance coefficient between Japanese and European types

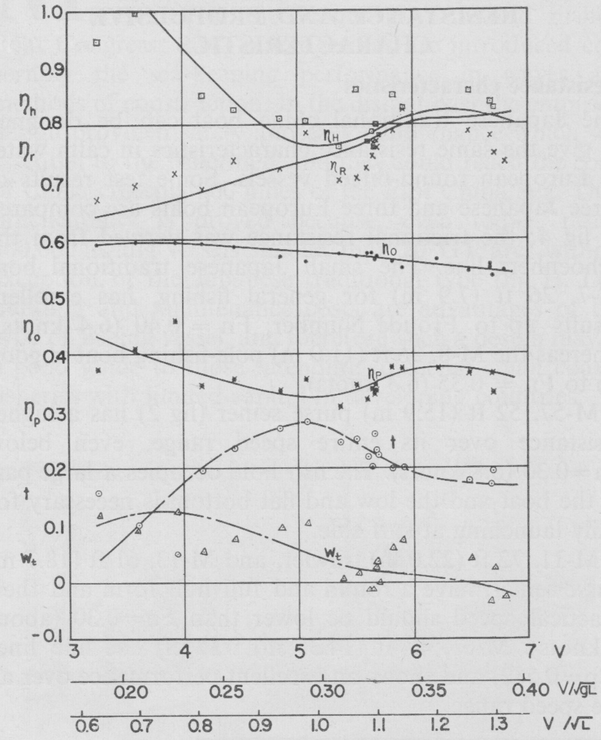

Fig 5. M-7 self propulsion test results

Generally the trim and draft affect the resistance of the chine form, especially in the lower speed range, Fn = 0.25, whereas at higher speeds above Fn = 0.30 the longitudinal volume distribution has more effect on the resistance of both types, chine form and round bottom form, than the sectional shape. This may be proved by the results of M-57 (chine, Cp = 0.710) and M-13 (rounded, Cp = 0.681). In the initial design stage, therefore, the trim of the draft should be decided considering chine and sectional area curve. For small boats the hydrodynamic flow velocity is so high that the flow along the hull may separate from the angular edge and the effect of volume may become much higher than the eddy-making resistance caused by the polygonal section-shape.

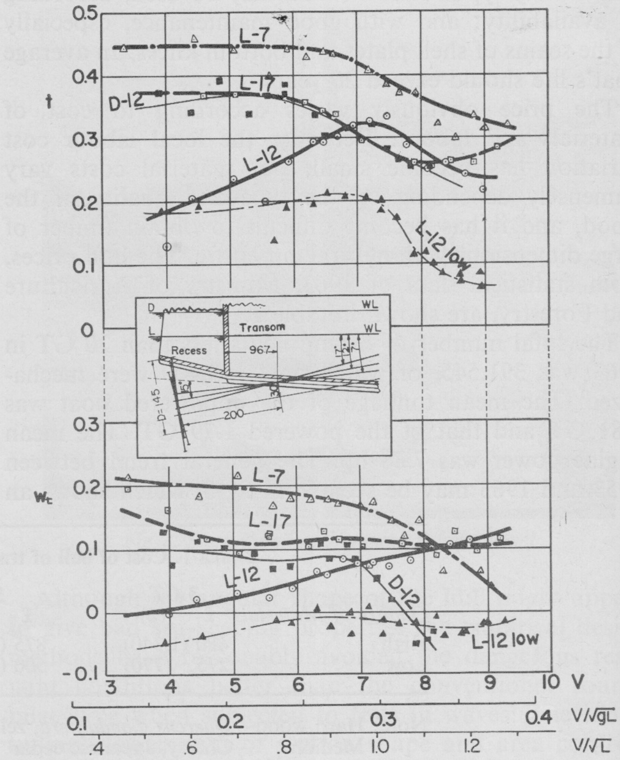

Fig 6. M-57 variation of wake fraction and thrust deduction coefficient due to propeller position

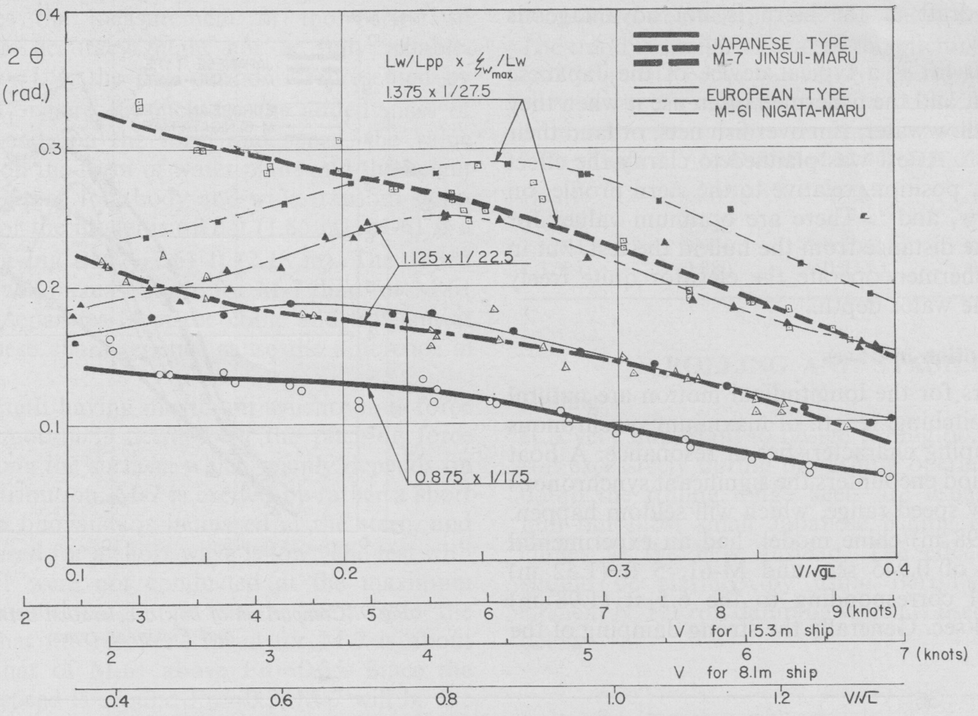

Fig 7. Comparison of pitching amplitude between Japanese and European types

Calm water propulsive characteristics

In spite of the good resistance characteristics, the disadvantage of the Japanese boat lies in the low propulsive characteristics. These are difficult to improve because stern construction is not easy to simplify further than the existing transom. The propulsive factors of M-7, 26 ft (7.9 m) are given for tests with a 2-m model (fig 5). The wake fraction, w_t is quite small and disadvantageously decreased from 0.1 to 0 or negative depending on the increase in speed, Fn=0.2 to 0.4. On the other hand the relative rotative efficiency, η_r, of the propeller rises from 0.7 to 0.8 with the speed but is much lower when compared with ordinary ships. The thrust deduction factor, t, is rather small, possibly because of the suction effect at the submerged transom but in the higher range from Fn=0.25 to 0.4, it rises up to the normal value of 0.2. The hull efficiency results from w_t and t, and so remains in the order of 0.8 and the resultant propulsive coefficient η_D=Pe/Pd is between 0.3 to 0.4 depending on the speed.

Effect of propeller position

Since the stream flow line cannot follow around the angular square stern, and the flat bottom gives low w value, the Japanese traditional boats must have an excessive thrust deduction.

When a propeller is put parallel to the flow, separated from the transom edge, and its centre immersed at least to its radius, the hull efficiency should become 100 per cent, but in practice the loss due to an increase of the thrust deduction fraction t will always exceed the small gain of w_t. This presumption was made quantitatively evident in tests in fair conditions, namely, with the propellers raked at 7°, 12° and 17° to the standard WL, plus less immersion at 12° of rake, as illustrated in fig 6. The result shows that L-12 deep immersion has the best hull efficiency above 9 knots followed by L-12, L-17, L-7 respectively, where L-12 may be affected by the influence of the rake. The negative wake has been derived from the potential flow along the hull surface and the deep immersion of propeller gives a hull efficiency over 90 per cent,

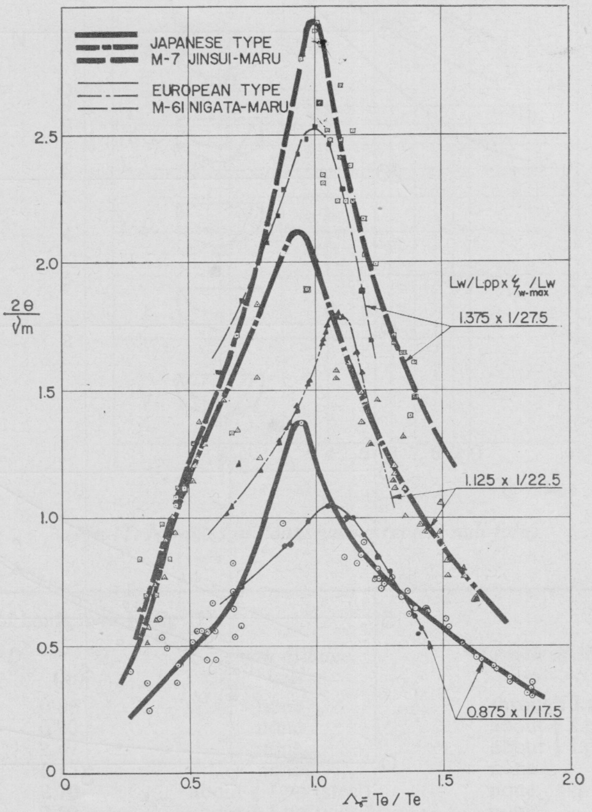

Fig 8. Comparison of pitching amplitude between Japanese and European types

but a deeper draft at the stern is not advantageous both to t and w_t.

The propeller lift is a typical device of the Japanese traditional boat, and the fishermen often use it when they navigate in shallow water, run over fish nets, or land their boat on a beach. A test was planned to clarify the effect of the propeller position, relative to the stern profile, on the factors of w_t and t. There are optimum values for the rake and the distance from the hull in the test, but in practice the fishermen operate the elevator quite freely according to the water depth.

Longitudinal motion in waves

Essential factors for the longitudinal motion are natural period of free pitching, length of maximum synchronous wave, and damping characteristics at resonance. A boat of long free period encounters the significant synchronous wave in the low speed range, which will seldom happen. M-7, 6.5 ft (1.98 m) chine model, had an experimental natural period of 0.945 sec, and M-61, 5 ft (1.52 m) rounded model corresponding to the 6.5 ft (1.98 m) model, of 0.804 sec. Generally the strong damping of the

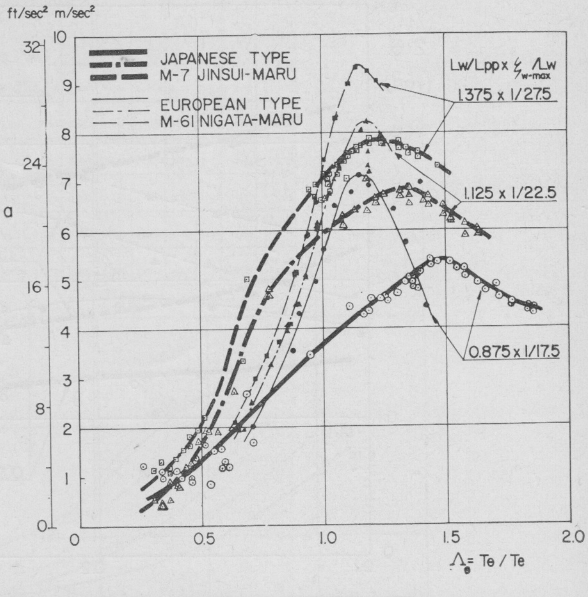

Fig 9. Comparison of bow acceleration between Japanese and European types

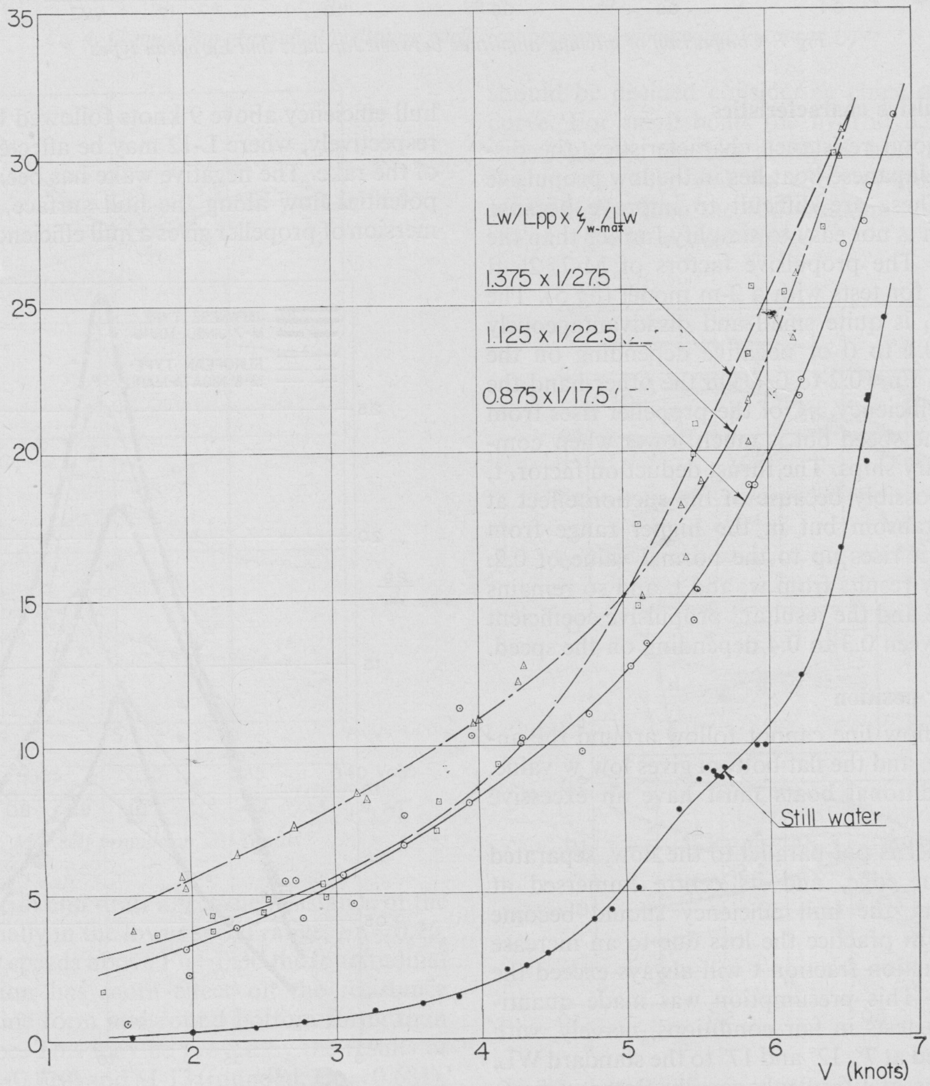

Fig 10. Increase in still water SHP due to waves

motions makes the measurement of the period so difficult that its accuracy might not be fully reliable. Assuming $K_{yy}=L/4$, the free period is represented by $2\,\pi K_y/\sqrt{gGM_1}$ where Ky includes the added mass of water and depends on the form and speed, the value GM_1 depends on the form of water plane and the height of G. M-7 has a fine fore body and wide transom stern, and the BM_1 for the model is 6.11 ft (1.85 m). M-61 is a normal boat having $\overline{BM}_1=7.61$ ft (2.18 m). The added mass of water will increase more for M-7 than for M-61 when the flow separates from the chine and transom at high speed. These characteristics cause the difference in the free period.

The wave length having maximum synchronous force on the ship's motion is decided by the pitching force distribution along the surface, which mainly depends on the volume distribution. M-7 is excited by rather a short wave, since the buoyancy is increased at the stern, and the resonant speed for a short wave is low. The test with M-7 and M-61 were not conducted at the maximum synchronous conditions, but it can be seen from the result (fig 7) that the resonant speed for M-7 is about Fn=0.1 and that of M-61 above Fn=0.25. Since the usual running speed is around Fn=0.3, M-7 will be the more comfortable in waves.

When a boat meets the synchronous condition, the motion depends upon the damping effect of the hull form. At a first glance, the flat chine form seems to have a longer synchronous motion in the maximum exciting condition, but the result in fig 8 is contrary to expectations, although further study should be made on this subject, as well as the relationship between dynamical exciting and damping.

M-7 has so fine a fore body and so full a stern that the resultant motion of pitching and heaving may bring the virtual centre of pitching rather aft. The combined effect of acceleration of pitching and heaving at the bow is smaller for M-7 than M-61 (fig 9). Such a result comes from the phase difference between them, where the heave of M-7 is in advance of its pitch, but on the other hand the pitch of M-61 is only a little in advance of its heave.

Power increase in waves

To maintain the same speed in waves as in calm water, the power should be increased and the more violent the motion the more power is required. Self-propulsion in rough water tests were run with M-7 (fig 10) but the M-61 model was too small to fit the dynamometer and so the model was towed in the same waves. Table 2 is the ratio of the increase of SHP to that of EHP, assuming propulsive coefficients are the same for both models. The trend is similar to that of the pitching amplitude, and M-7 is a little better than M-61 above Fn=0.26.

TABLE 2. **△SHP/SHP of M-7/△EHP/EHP of M-61**

Wave	*Fn*=0.26	0.30	0.34	0.38
0.875 L	0.902	0.675	0.773	1.300
1.125 L	0.986	0.705	0.697	0.925
1.375 L	0.880	0.735	0.772	0.870

ROLLING AND STABILITY

Rolling

It is very important to design fishing boats which do not roll excessively during the fishing operation. In order to damp the rolling, bilge keels are usually fitted to the hull but most small Japanese fishing boats have hard chines at the bilge instead. The effect of the chines should be clarified by using Bertin's extinction coefficient N, for roll damping which is used in the example below.

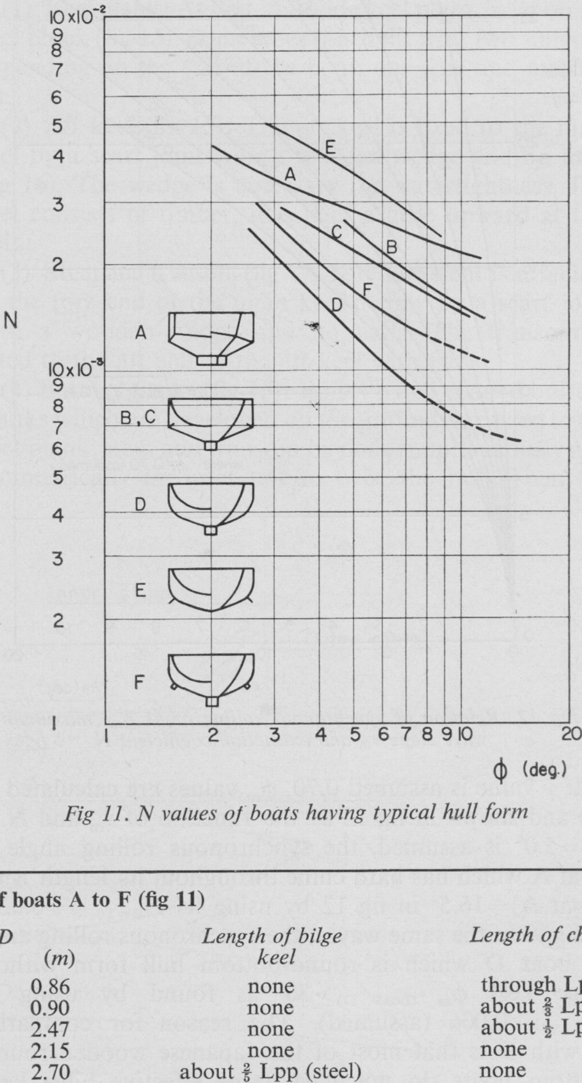

Fig 11. N values of boats having typical hull form

TABLE 3. **Principal dimensions of boats A to F (fig 11)**

Mark	*Lpp*		*B*		*D*		*Length of bilge keel*	*Length of chine*
	ft	*(m)*	*ft*	*(m)*	*ft*	*(m)*		
A	26.2	8.00	6.77	2.06	2.82	0.86	none	through Lpp
B	29.5	9.00	6.56	2.00	2.95	0.90	none	about ⅔ Lpp
C	80.01	24.42	18.05	5.50	8.10	2.47	none	about ½ Lpp
D	68.50	20.88	14.40	4.40	7.05	2.15	none	none
E	95.20	29.00	17.70	5.40	8.86	2.70	about ⅖ Lpp (steel)	none
F	78.20	23.80	17.65	5.39	8.50	2.59	about ⅖ Lpp (wood)	none

(1) **N coefficient:** The values of extinction coefficient measured for many actual boats operating under load conditions are shown in fig 11. Their principal dimensions are shown in table 3. The lines plan of "A" marked in fig 11 are shown in fig 23. Fig 11 shows clearly that the N value of A is the largest, with the exception of E. This indicates that the damping action of the hull form having hard chines throughout its length is greater than those having partial or no chines. The damping action of A is rather comparable with that of E which has sharp-edged bilge keels made of steel. The actual effect of these N values is shown as follows:

(2) **Comparison with round-bottom boats:** When a boat rolls synchronously on a regular beam swell having the maximum wave slope ν_m (degree), the maximum rolling angle is calculated by:

$$\phi_m \doteqdot \sqrt{\pi\gamma\nu_m/2N}\ \text{(degree)} \qquad (1)$$

where γ is effective wave slope coefficient.

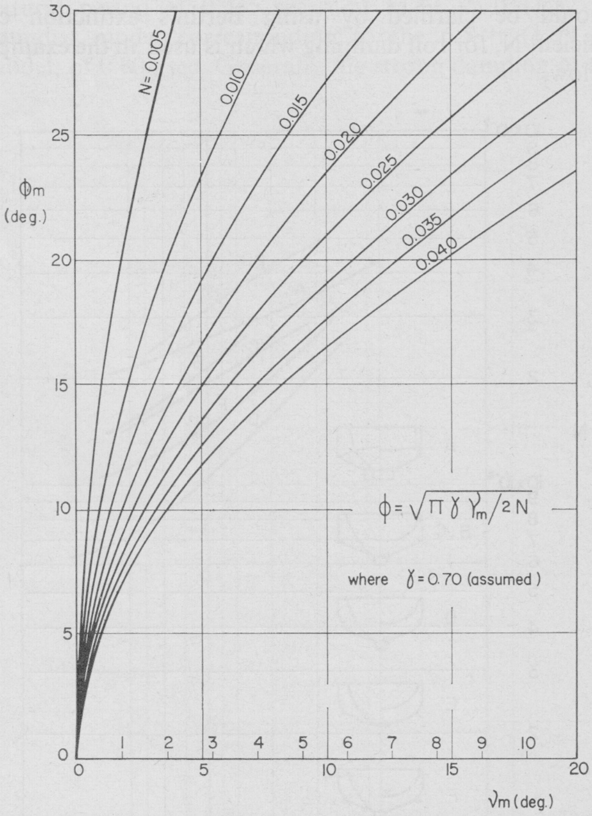

Fig 12. Relation of synchronous rolling angle ϕ_m, maximum wave slope ν_m and extinction coefficient N

If γ value is assumed 0.70, ϕ_m values are calculated by (1) and shown in fig 12 as the function of ν_m and N. If $\nu_m = 5.0°$ is assumed, the synchronous rolling angle of boat A which has hard chine throughout its length is ϕ_m (boat A)$\doteqdot 16.5°$ in fig 12 by using its $N_{\phi=16\cdot5°} \doteqdot 0.020$* in fig 9. In the same waves, the synchronous rolling angle of boat D which is round-bottom hull form without bilge keel $\phi_{m\ (\text{boat D})} > 30°$ is found by using its $N_{\phi=30°} \doteqdot 0.006$ (assumed). The reason for comparing A with D is that most of the Japanese wooden round-bottom boats do not have large effective bilge keels because of the fear that the watertightness of the shell plank around such a keel might easily be broken by accidents.

TABLE 4. **Comparison of boats A and D**

Boat	*Maximum circular velocity*	*Maximum circular acceleration*
A	2.0 ft/sec (61 cm/sec)	4.2 ft/sec^2 (128 cm/sec^2)
D	>3.6 ft/sec (>110 cm/sec)	>7.6 ft/sec^2 (>230 cm/sec^2)

Note: 1. wave period, Tw: 3.0 sec (=Ts when synchronized)

wave length, λ:	46 ft (14 m)
maximum wave slope, ν_m:	5.0°
maximum wave height, H_w:	1.3 ft (39 cm)
H_w/λ:	1/36

2. Limit value of unbearable acceleration

by Kempf	1.97 ft/sec^2	(60 cm/sec^2)
Inoue	3.93 ft/sec^2	(120 cm/sec^2)
Kawashima	6.55 ft/sec^2	(200 cm/sec^2)

3. Maximum circular velocity at the deck edge

$$\doteqdot \frac{B}{2}\,\phi_{max}\,\frac{2\pi}{T_\phi}\ \text{(where } \phi_{max}=\text{radian)}$$

Maximum circular acceleration at the deck edge

$$\doteqdot \frac{B}{2}\,\phi_{max}\left(\frac{2\pi}{T_\phi}\right)^2\ \text{(where } \phi_{max}=\text{radian)}$$

Under such rolling conditions, the circular maximum velocity and acceleration at the deck edge of each boat is shown in table 4. (Assuming the breadth B = 2.0 m and free rolling period $T_s = 3.0$ sec). The difference in the results are thought to be significant from the fishing efficiency viewpoint in rough seas. In Japan, some pole-fishing boats are designed empirically to make them as close to the permissible lower limit of stability with lower $\overline{KG}/D$ value and hard chined hull form. This is reasonable because they have longer rolling period, T_s, smaller effective wave slope coefficient, γ, and higher extinction coefficient, N, and so have a tendency to roll more slowly and to smaller angles.

In Japan, there is a small number of round-bottom wooden fishing boats having wooden bilge keels, but their N values are much smaller than those that have sharp-edged bilge keels made of steel (fig 11). This is because the keel depth is rather small and the edge not usually sharpened. On the other hand, the sharp-edged chines of vee-shaped boats are thought to be quite effective to damp the rolling.

(3) **Fishing platform:** Most of the Japanese small fishing boats have fishing platforms outside of both deck edges, as shown in fig 22, 23 and 24. These parts are actually not watertight and therefore do not affect $\overline{GZ}$ curves in a rough sea. They are known, however, empirically to be quite useful in damping rolling, although systematical analysis of this has not been performed.

Stability

There is no basic criterion to judge the stability of small fishing boats in rough seas and therefore, in order to compare it, the theory of C value (Yamagata, 1959) now being used in Japan for passenger ships has been used for the small fishing boats.

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* ≑ approximately equal to.

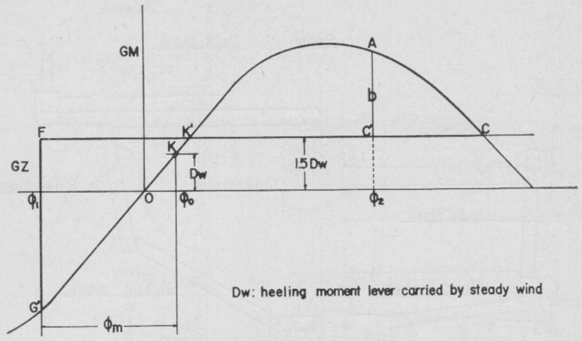

Fig 13. Explanatory diagram of C coefficient

(1) **Wind and waves:** When boat A heels by ϕ_0 degrees to the lee side under steady beam wind, the boat rolls around ϕ_0, and rolls to the maximum rolling angle ϕ_1 (fig 13) on the weather side under synchronous rolling. If a gust blows suddenly from the same direction, the boat rolls much further to the heeling angle ϕ_2 on the lee side, where area K′G′F = area K′C′A as shown. The heeling moment lever of the gust around Japan is nearly 1.5 times of the steady wind. Therefore, if area K′G′F = a and K′C′A = b are measured on the diagram, and $b/a > 1$, the boat is considered to be safe.

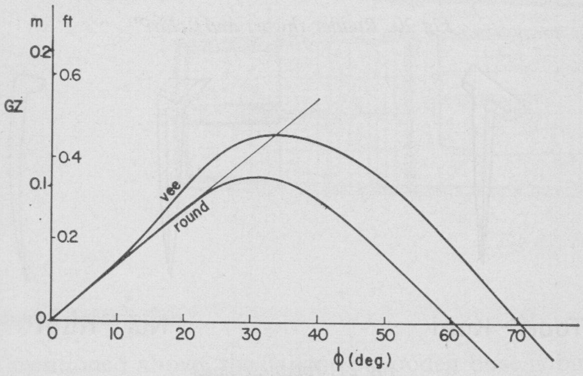

Fig 14. Comparison of GZ curves of Vee- and round-bottom boat

If the stability of a vee-shaped boat is compared with that of a round-bottom boat having the same $\overline{GZ}$ curve, the former is safer, as N value of the vee-shaped boat is larger, and therefore ϕ_m of the former is smaller.

(2) **Strong wind or deck water:** It is evident that the boat having a larger GZ maximum value is safer when the boat receives only a constant heeling moment caused by, say, a strong wind or deck water. GZ curves are compared between vee-shaped and round-bottom boats of equal displacement (fig 14). In this comparison the latter's bilge is amended into round form from the former's lines drawing by using a radius = B/4, and $\overline{GM}$ and freeboard are accordingly modified. The comparison indicates that the vee-shaped boat is less dangerous than the round-bottom boat under steady heeling moment.

CONSTRUCTION

The construction methods employed in the building of traditional Japanese boats are of great interest because they are simple and cheap.

Building procedure

(1) **Keel plank:** At first, the wide keel plank is set on the keel block (fig 15). Sometimes it is built with two timbers, depending on the size of the boat, one fore and another aft.

(2) **Aft keel (fig 15):** The aft keel is fixed to the main keel by a scarf joint with a wooden wedge and no nails (fig 16). The wedge is necessary for watertightness. If a keel consists of timber, it is bent a little upward at this point.

(3) **Stem and transom (fig 17, 18):** The stem is attached to the fore end of the main keel mainly by a scarf joint with a wooden wedge and no nails. The transom is fitted to the aft end of the aft keel with nails.

(4) **Bottom planks (fig 15):** Built up and shaped bottom planks which are developed on the ground, are fixed to the keel plank, stem and transom by nails simultaneously and symmetrically in order not to twist the hull. Then the

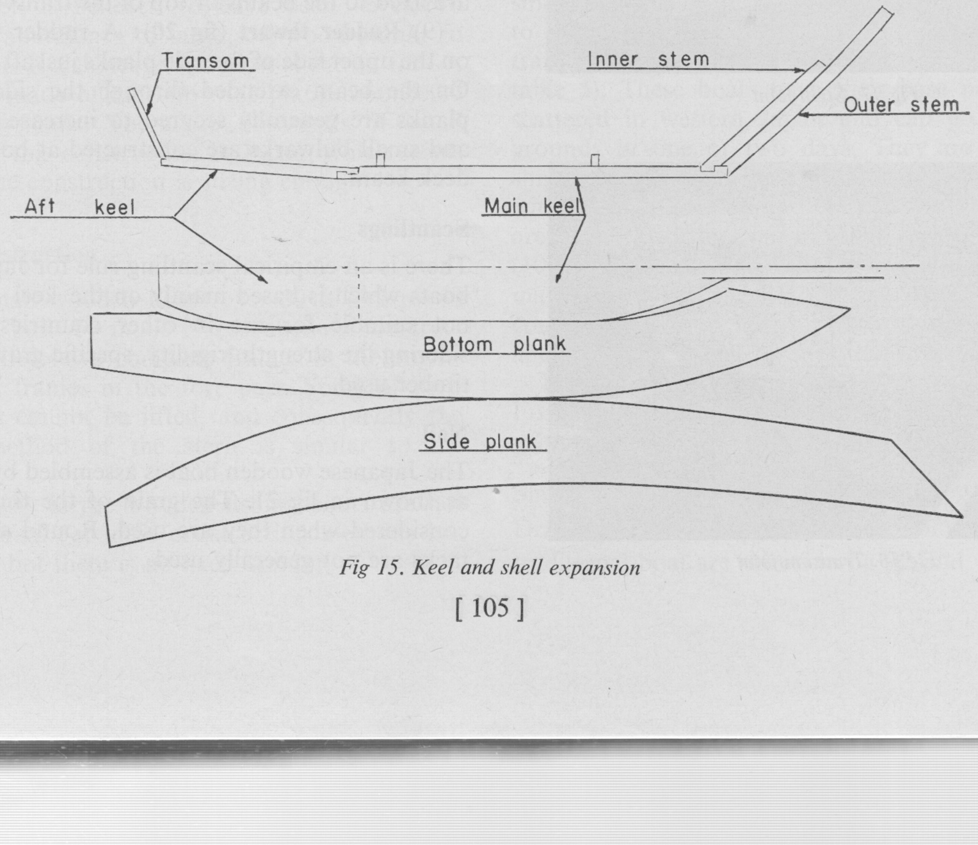

Fig 15. Keel and shell expansion

rise of floor is settled at several fixed positions and upper edges of the bottom plank are smoothed symmetrically.

(5) **Floor timber (fig 19):** Built up and shaped floor timbers are fixed in set positions to the bottom planks by nails. If a transverse bulkhead is necessary, it is built up, usually on the floor timber.

(6) **Side planks (fig 15 and 19):** Shaped side planks on both sides are fixed to the bottom planks, stem and transom, from midships towards both ends. Simultaneously the distance of their upper edge is fixed by temporary small tying timbers. The aft ends of shell planks are extended a little, then cut. The aft edge is covered by small planks.

(7) **Side frames (fig 19):** Side frames, or sometimes bilge brackets only, are fixed to shell planks at essential points. Side frames are unnecessary near transverse bulkheads.

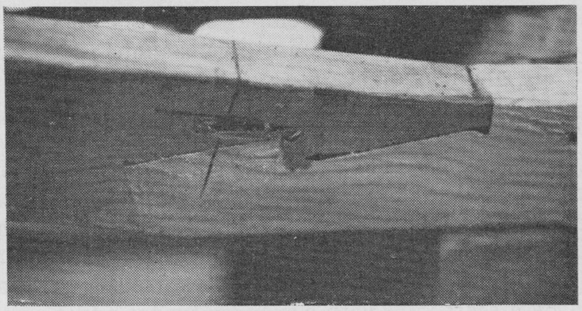
Fig 16. Keel joint


Fig 17. Stem joint


Fig 18. Transom joint

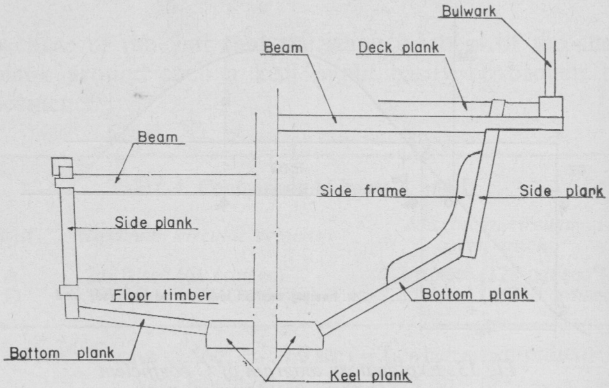

Fig 19. Two sections

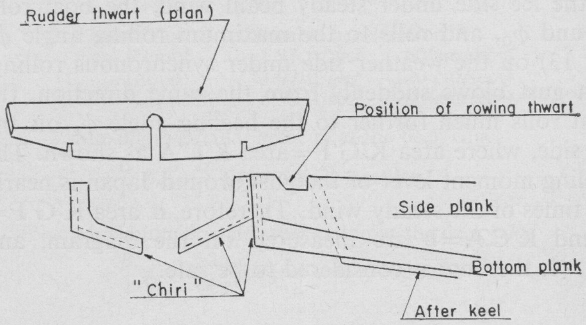

Fig 20. Rudder thwart and "chiri"

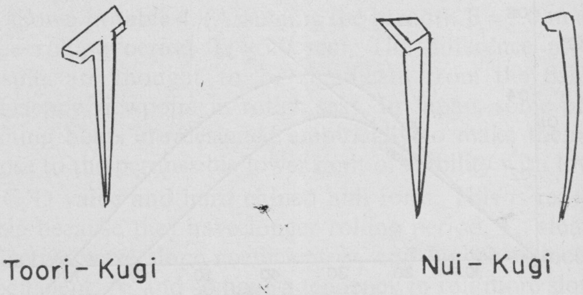

Fig 21. Japanese nails

(8) **Beam and deck plank (fig 19):** Beams are fixed through side planks at their upper edge. The deck planks are fixed to the beams or top of the transverse bulkheads.

(9) **Rudder thwart (fig 20):** A rudder thwart is fixed on the upper side of the side planks just aft of the transom. On the beam extended through the side planks, deck planks are generally secured to increase the deck area, and small bulwarks are constructed at both edges of the deck beam.

Scantlings

There is an empirical scantling rule for Japanese wooden boats which is based mainly on the keel length but it is not suitable for use in other countries without considering the strength, rigidity, specific gravity, etc., of the timber used.

Nail

The Japanese wooden boat is assembled by a special nail, as shown in fig 21. The grain of the timber should be considered when they are used. Round section bolts or tacks are not generally used.

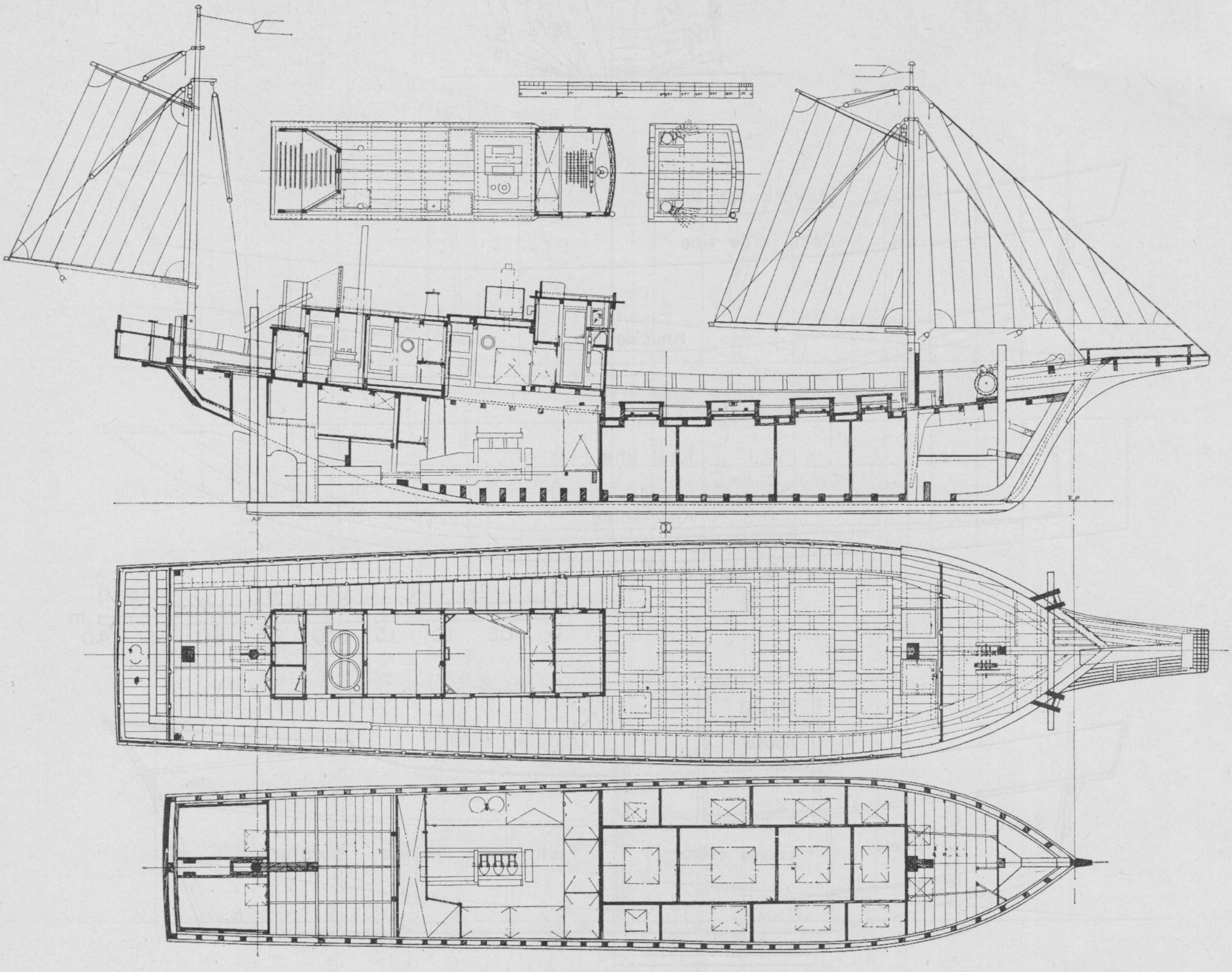

Fig 22. 20 GT mackerel boat

General description

As mentioned above, the Japanese wooden boat is built on basic simple sectional shapes by utilizing the flexibility of soft-wood planks, and therefore it does not require skilled techniques in the design and building. The construction is believed to have been developed because of the abundance of large soft-wood planks in Japan. Now there is a shortage and most of the bottom or side planks are made of built-up wide planks connected side by side by nails. There are thousands of small fishing boats of this construction in Japan, which seems to prove that the construction is strong enough.

Modernized construction

Most of the small wooden boats over 30 ft (9.2 m) in length are now built by modernized Japanese construction (fig 22). They have complete frames in the engine room and cant frames in the fore part. Some of their propeller shafts cannot be lifted, and consequently the construction method of the stern is similar to the European.

The reason why larger wooden fishing boats are not built by traditional Japanese construction methods has been discussed, but there is no fixed opinion.

EXAMPLES OF ACTUAL BOATS

Group fishing boats

To raise the efficiency of fishing in some areas, the group-fishing system has been introduced, consisting of a 10- to 20-GT mothership and about ten 2- to 3-GT small boats. The mothership guides the catcher boats to the fishing grounds and, after fishing, gathers and transports the catch to a suitable market (fig 23 and 24, table 5). These boats have their base ports on islands scattered in western Japan and can go to the fishing grounds in one or two days. They are built in small shipyards by traditional and rather simple methods, without any calculations, but the fishermen claim they are very seaworthy even in rough seas of 32 to 38 ft/sec (10 to 12 m/sec) wind velocity and about 7.6 ft (2.5 m) maximum wave height and can also operate under conditions of 26 to 32 ft/sec (8 to 10 m/sec) wind velocity and about 3.7 ft (1.2 m) maximum wave height.

The mothership shown in fig 24 was designed by the Fishing Boat Laboratory, the main objective being to give it enough seaworthiness and stability.

Small mackerel pole-fishing boats

Drawings and principal dimensions of a typical Japanese traditional boat are shown in fig 22 and in table 6. $\overline{GM}$

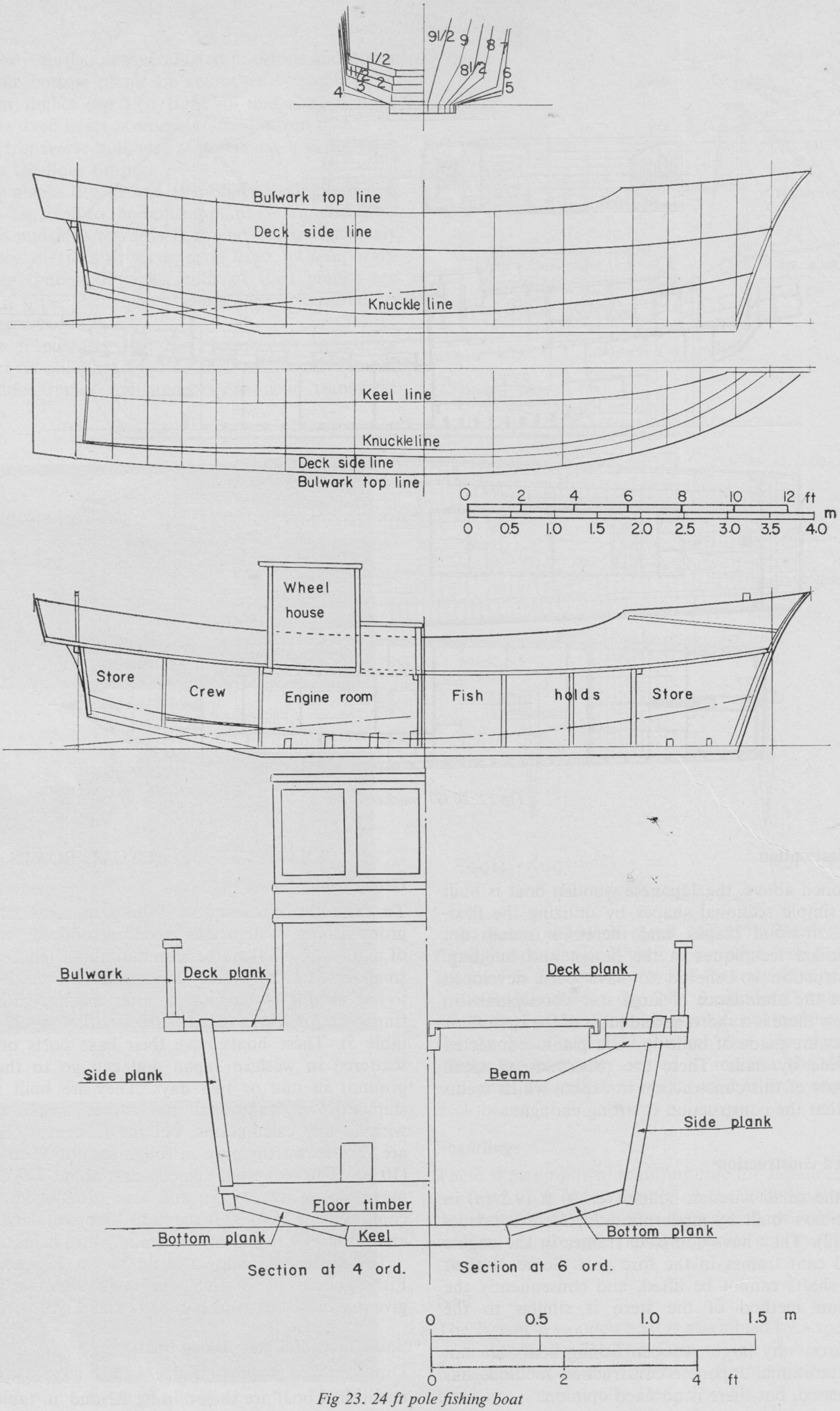

Fig 23. 24 ft pole fishing boat

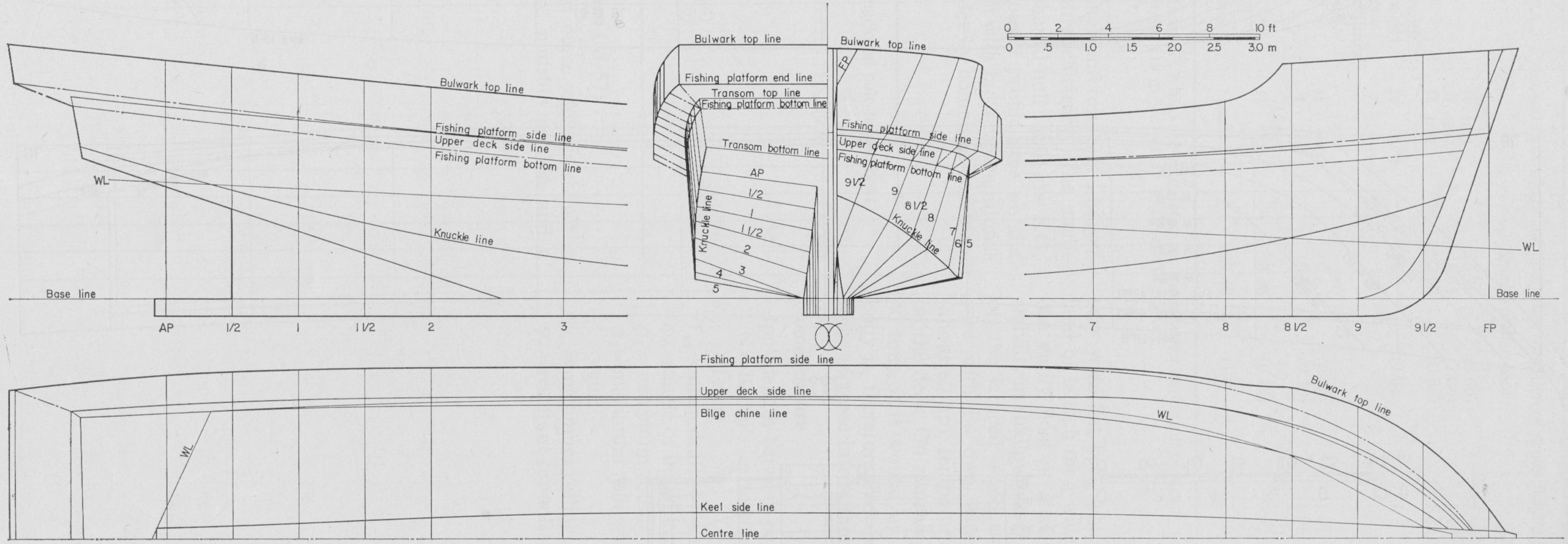

Fig 24. Mothership

Fig 25. Lines of a flat-bottom purse seiner (M-57)

TABLE 5. **Principal dimensions and operating condition of group fishing boats**

		Small catcher boat		*Mothership*	
GT		2.8		19.9	
Lpp	ft (m)	26.20	(8.00)	52.50	(16.00)
B	ft (m)	6.75	(2.06)	11.15	(3.40)
D	ft (m)	2.82	(0.86)	5.25	(1.60)
hp of main engine		17		120	
Fish-hold capacity	ft³ (m³)	105.8	(3.0)	777	(22.0)
Number of crew		2		7	
Operating condition					
Displacement	ton	6.5		50.4	
$\overline{GM}$	ft (m)	0.85	(0.26)	1.41	(0.43)
Freeboard	ft (m)	0.99	(0.30)	1.05	(0.32)
$\overline{GZ}$max	(deg)	32		35	
	ft (m)	0.46	(0.14)	0.82	(0.25)
C coefficient		1.6		2.0	
Wind velocity	(m/sec)	39.40	(12)	62.30	(19)

Note: C coefficients (=b/a) are calculated for the weather condition of steady wind velocity of 62.30 ft/sec (19 m/sec) or 39.40 ft/sec (12 m/sec).

value of these boats is rather small and results in a longer rolling period and high fishing efficiency. The main reasons for this are their vee-shaped hull form, low $\overline{KG}$, narrow breadth and little exposed profile area on the water line. The fish pond is built with Japanese traditional type construction, the remainder by combined construction.

TABLE 6. **Data of vee-shape mackerel pole-fishing boat**

GT		19.50
L×B×D	ft (m)	55.70 (16.95)×11.52 (3.52)×5.45 (1.66)
hp of main engine		75
Fish-hold capacity	ft³ (m³)	797 (22.6)
Full load condition		
Displacement	ton	56.9
$\overline{GM}$	ft (m)	0.79 (0.24)
Freeboard	ft (m)	1.18 (0.36)
$\overline{KG}$/D		0.75

Coastal purse seiner Sakai-Maru (M-57)

The lines drawing of a coastal purse seiner is shown in fig 25. It has a nearly square midship section and a very wide flat keel, which makes it very convenient to land or launch on a wide shallow beach. This hull form can easily float at a small draft and also has enough stability in shallow waves or water. The boat is launched on the latticed wood (fig 1) by winding an anchored wire with its own winch driven by its main engine (about 60 hp), temporarily cooled by water in a drum on the deck. On returning with a displacement of nearly 40 tons, it is wound up by a shore winch. The square body is, therefore, indispensable to such operations and some increase in resistance must be accepted (fig 4).

Nomenclature

lpp = length between perpendicular of a model

N = Bertin's extinction coefficient for roll damping force

T_m = mean draft

ϕ_0 = angle of initial keel

ϕ_1 = maximum rolling angle by synchronous wave

ϕ_2 = maximum rolling angle by synchronous wave and gust

ϕ_m = maximum rolling angle

γ_p = resultant propulsive coefficient = Pe/Pd