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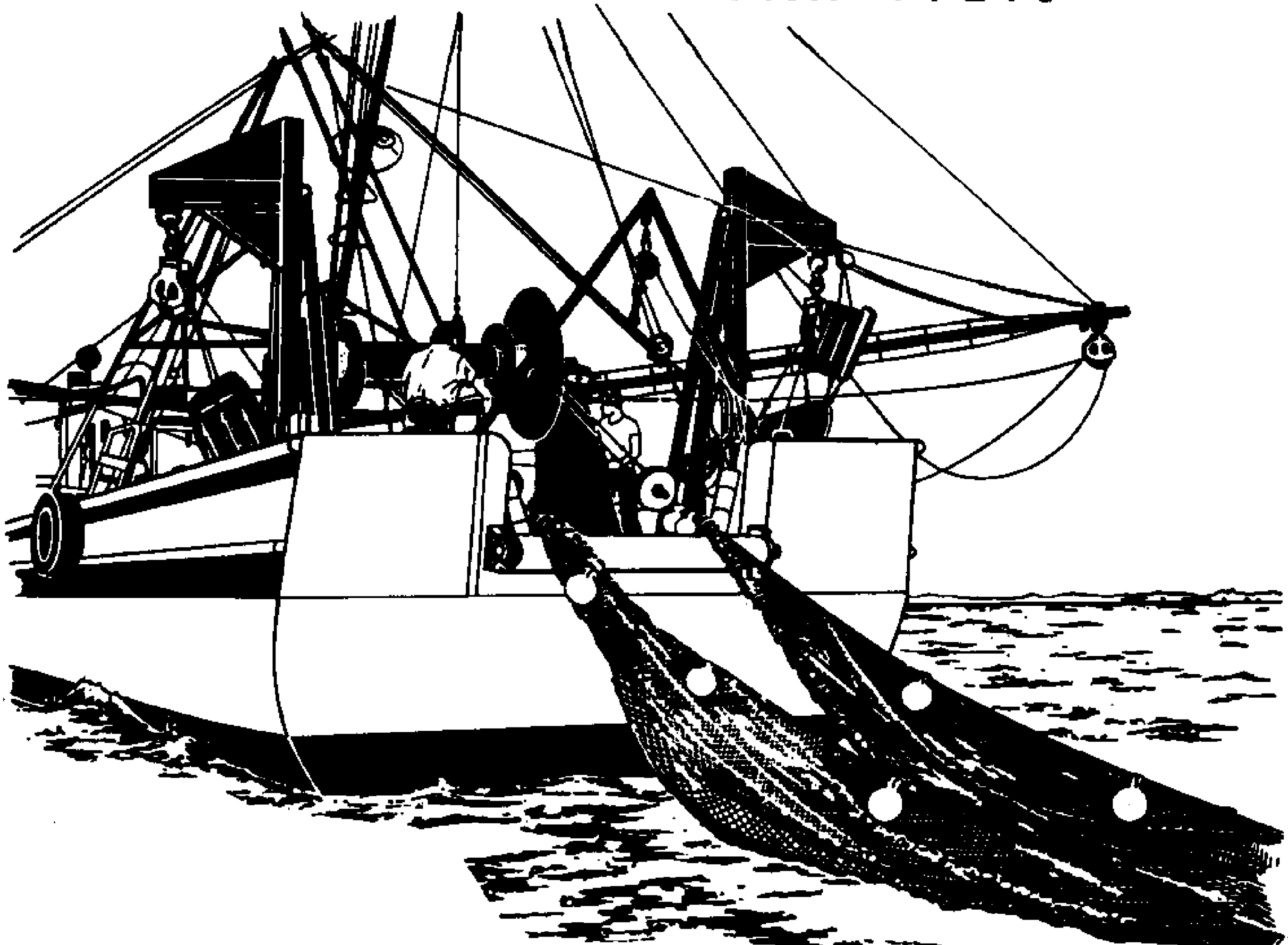
OTTER DOORS AND FUEL CONSUMPTION



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By

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A considerable part of the total drag of fishing gear is due to the trawl doors. Trawl doors typically cause about 30 percent of the total drag. For a particular boat, propeller and engine combination the amount of fuel you burn when trawling depends directly on the speed that you trawl and on the drag of the trawling gear. If you double the drag of the trawling gear and maintain the same speed you'll burn twice as much fuel. Since trawl doors typically account for 30 percent of the total drag they also account for 30 percent of the fuel burned while trawling. The doors' drag is an undesirable by-product of the doors' primary function of spreading the net. If you could keep the same spreading ability while reducing the drag of the doors, you would save money and reduce your fuel consumption. Three possible ways of doing this are to eliminate doors, use the doors more efficiently or use more efficient doors.

- Eliminate Doors

One way of eliminating doors is by the trawling method known as pair trawling. In this method two boats pull a single net. The boats pull side by side at a set distance apart spreading the net and dragging it behind them. Because the boats are spreading the net, there is no need for trawl doors. This method requires close cooperation between the two captains and works best with two boats that are closely matched in power. In addition the fishing grounds must be suitable for this type of operation. For example, there should be room enough for the two boats to trawl side by side and the bottom should be fairly level. By using this method the two boats can pull a larger net than a single boat with the same horse power as that of the combined power of the two boats.

It is not necessary to pair trawl to eliminate doors. For example, twin rigs have eliminated a set of doors for years. That is, two nets are pulled on each side with only one complete set of doors. Instead of an inner door on the outer net and outer door on the inner net on each side a dummy door or sled is used. This reduces the drag that would have occurred had full sets of doors been used on each net. This same idea can also be applied to double-rigged boats or to boats pulling a single net. For example, in a rigging referred to as the Easy Rig, the inner doors of a double rigged vessel are eliminated and replaced by dummy doors and a cable connecting the two dummy doors. The only doors which do spreading are the outer doors of each net. As of this writing, Captain Wallace Styron is conducting a result demonstration with this rig. By eliminating half of the doors and the drag that goes with them, Captain Styron is able to reduce engine speed by 150 RPM and still maintain the same trawling speed. He estimates that his fuel saving is at least 10 percent and probably 15 percent with this rig and he has seen no difference in the amount of shrimp caught as compared to the standard rig. Since the doors typically account for 30 percent of the fuel consumption, Captain Styron's estimate of 15 percent corresponds well with eliminating half of the drag of the doors or 15 percent of the total drag and total fuel consumption of the fishing gear.

The Ponchatrain rig or bay sweeper is a method of rigging a single net to reduce the drag of doors and the fuel consumption. This rig is applied to single nets operating in shallow water such as Lake Ponchatrain. In this rig the bridle arrangement in which the two doors are bridled to the towing line is not used. Instead, a cable running from an outrigger on each side of the boat to the respective door is used. The cable comes off a rigid pole which drops down from the outrigger. This permits shorter warps while still permitting the door to have bottom contact. By rigging the trawl in this manner the inward pull exerted by bridle on the door is eliminated and thus, since the door does not have to overcome this inward pull, it can be much smaller and still open the net as wide as doors in the conventional rig. This should result in a fuel savings with the same size net or for the same fuel consumption the ability to pull a larger net.

Another way of improving efficiency is to use the trawl door more efficiently. For example, the National Marine Fisheries Service film, "Shrimp Trawls Design and Performance" several variations in door settings, trawl types and door sizes are shown and the corresponding effect on net shape and performance. This information is summarized in the publication Shrimp Trawls: Performance and Efficiency available through your marine advisory agent.

The forces produced by a door can be broken down into a drag force and a force which spreads the net. The drag force is referred to as the drag while the force that spreads the net is referred to as either a shear, spreading force or lift. Most often, doors are characterized not by the absolute value of the drag and spreading or lift forces, but by coefficients of lift or shear and drag. The actual forces the door exerts is obtained by multiplying the area of the door times the velocity squared times the coefficient. By presenting the information in this manner many doors of different sizes but of the same type are covered and their coefficients are nearly independent of speed. For example, Figure 1, shows the coefficient of lift and coefficient of drag and the ratio of the lift to drag coefficient for a flat rectangular otter door at different angles of attack.

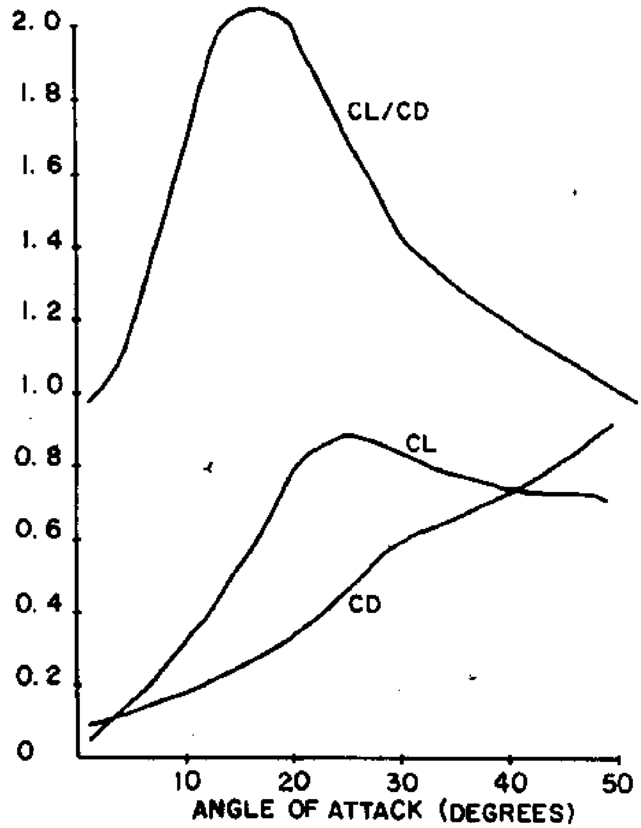

FIG.I COEFFICIENTS FOR RECTANGULAR FLAT DOOR

Look first at the line labeled CL or coefficient of lift. As the angle of attack increases up to about 20 or 25 degrees the coefficient of lift also increases. This means that as you increase the angle of attack of the board up to about 20 or 25 degrees, you will get more spreading force. After about 25 degrees the coefficient of lift decreases as the angle of attack is increased. This means as you go to greater angles of attack past about 25 degrees you actually get less spreading force. For example, a board at 50 degrees would have slightly less spreading force than a board at 30 degrees. However, the drag which that board produces increases continuously as you increase the angle of attack. That is shown by the line labeled CD for coefficient of drag. Thus, after about 25 or 30 degrees, increasing the angle of attack gives you no more spreading force but it does increase the drag of a door. A measure of the efficiency of the door could be obtained from looking at the ratio of the lift to drag coefficient or the spreading to drag force. This is plotted in the curve of CL/CD. Notice that this curve peaks at about 20 degrees which is saying that for the same amount of drag you get the most spreading force at an angle of attack of about 18 or 20 degrees. Past this point for the same amount of drag you get less spreading force. From the standpoint of efficiency then, the angle of attack of the board would only be about 20 degrees. If more spreading force is needed, you would go to a larger board. However, this is not usually done in practice because the smaller angle of attack tends to decrease the stability of the board. Obviously a compromise is needed and the usual angle of attack for most otter boards in the shrimp fishery is around 30 to 35 degrees. The angle of attack of the board is just one of the parameters that can affect efficiency. For a more complete discussion of other parameters please refer to Reference 1, Trawl Fishermen's Gear Technology Manual by Duncan Amos. This is also the source for the data presented in Figure 1.

● Use More Efficient Doors

The rectangular flat wooden door has been in use since 1890's. The basic design has not changed much since that time. It is not a fuel efficient door since it has a high drag to lift ratio rather than high lift to drag ratio which is desired for good fuel efficiency. They do have several good features which is probably why they are still in use. They are easy to stow, they are easy to build and relatively cheap. They are stable on both smooth and rough ground and can clear boulders or obstructions reasonably well. The biggest drawback is that they are not hydro-dynamically efficient and thus exact a penalty in fuel usage. They can comprise 30 to 35% of the total drag of the trawl gear and thus 30 to 35% of the fuel usage.

Many other board designs have been tried since 1890. Several of the more significant designs are the Cambered rectangular door, Vee doors and Polyvalent boards. In addition, many doors with slots have been tried to improve the hydro-dynamic efficiency of the boards. Table 1 presents data from the Scottish Fisheries Research Report #14, 1979, entitled: A Study of Bottom Trawling Gear On Both Sand and Hard Ground.

Table 2 reproduces Robert Sadat's (2) list of door characteristics.

TABLE 1

	Rectangular Flat Wooden	Polyvalent Steel	Cambered Rectangular Steel	Rectangular Vee Steel
Size, length breadth	5'8 X 3'3"	5'7" X 3'5"	5'8" X 2'11"	5'10" X 3'4"
Projected Area	17.8 sq. ft.	19 sq. ft.	16.5 sq. ft.	19 sq. ft.
Weight in air (lbs)	225	476	347	344
Weight Sea Water (lbs)	115	356	158	156
Average Board Spread on Sand (feet)	57.4	65.9	67.9	57.1
Average Board Spread on Rough Ground (feet)	55.1	49.5	58.4	49.5
Spreading Force per Sq. Foot on Smooth Sand (lbs. Sq. Foot)	12.3	11.4	13.4	12.1
Spreading Force per Sq. Foot on Rough Ground (lbs per Sq. Foot)	12	9.4	11.7	10.8
Mean Towing Tension on Smooth Sand at 3 knots (lbs force)	1663	1419	1430	1738

TABLE 2

SUMMARY OF MAIN OTTER BOARDS CHARACTERISTICS

Otter board type	Corresponding hydrodynamic characteristics					Fishing suitability			Construction considerations			Experience record
	Common angle of attack	Coefficients of shear CL	Coefficients of drag CD	Lift drag rates CL/CD	Overall efficiency	Maneuverability	On the sea bed[1]	In midwater	Extent of special skills and tools needed	Costs: Purchase	Costs: Maintenance	
1. Conventional rectangular flat	40°	0.82	0.72	1.14	Average to poor	Good	A,B good C poor	Poor	Average	Average	Average	Well proven; extensively used for demersal fishing
2. Rectangular flat wide-keeled	40°	0.82	0.72	1.14	Average to poor	Good	A good B poor C unsuitable	Poor	Less than average	Low	Low	Well proven; extensively used for small vessels and for shrimp trawling
3. Rectangular	35°	1.26	0.81	1.55	Good	Average (difficult to right if fallen over)	A,B good C poor	Poor	Above average (bending acilities needed)	High	Average	Very limited commercial use to date
4. Oval flat, slotted	35°	0.86	0.63	1.36	Average	Average to good	A,B,C good	Poor to average	Above average	High	Average	Well proven; widely used particularly by large trawlers
5. Oval cambered, slotted (polyvalent type)	35°	0.93	0.74	1.25	Average to good	Average to good	A,B,C good	Average to good	Above average (bending facilities needed)	High	Average	Recent development: use increasing
6. Rectangular Vee type	40°	0.80	0.65	1.23	Average to poor	Good	A,B,C good	Poor	Average	Average	Low	Well proven; extensive use, particularly for trawlers up to 600 hp
7. Rectangular flat special design (diverting depressor)	40°	0.82	0.72	1.14	Average to poor	Very good	A,B good C average	Average	High	Very high	Low	Recent development: limited commercial use so far
8. Rectangular cambered high aspect ratio for midwater trawling (Suberkrub type)	15°	1.52	0.25	6.08	Very good	Midwater good; bottom average to poor	A,B good C unsuitable	Very good	Above average (bending facilities needed)	Average to high	Low	Well proven; extensively used for midwater trawling by trawlers of all sizes
9. Rectangular cambered high aspect ratio, for bottom trawling (Japanese type)	25°	1.30	0.50	2.60	Very good	Average (risk to fall flat)	A,B good C unsuitable	Good	Above average (bending facilities needed	Average to high	Average	Extensive use but limited so far to Japanese trawlers

[1] For quality of seabed:
A - good ground, even, absence of boulders, etc.
B - medium ground, stones, no sudden major depth changes
C - bad ground, large boulders, uneven, sudden and major depth variations.

Of these doors, the one which has become most popular is the Vee door. Even though it is the most hydro-dynamically inefficient of all four doors listed. This is mainly due to its ease of handling and its ability to fish over rough ground. The Cambered rectangular door has good hydro-dynamic efficiency but has not become popular. Even though it has not been generally adopted the design features of this door is currently being used in some modern door designs which may have good application in the shrimp fleets in the Gulf of Mexico. One of these door types is the Bison trawl door which is currently being sold in the northeast and on the west coast. One of the major drawbacks of the Bison doors are that they are expensive. However, skippers report from 10 to 20% reduction in fuel costs with their use. Work is currently under way by Duncan Amos (Georgia Sea Grant) on developing a modified rectangular door which would employ a vertical slot at a 35 degree angle to improve the hydro-dynamic efficiency and still retain the desirable characteristics of the wooden rectangular door. This board offers very good possibility for the Gulf of Mexico fishery.

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