# الأبحاث المنشورة (1988-1993)

## فى مجال تصميم واقتصاديات سفن الصيد

## للأستاذ الدكتور محمد عبد الفتاح شامة

# Published Papers (1988-1993)

# on Fishing Vessels Design and Economics

## by

## Prof. Dr. M. A. Shama

1- "Factors Affecting Productivity of Coastal Fishing Vessel", AEJ, April, (Egypt-1988), Shama, M. A., (100%)

2- "Factors Affecting Fishing Voyage Expenses and Efficiency", AEJ, April, (Egypt-1988) , Shama, M. A., (100%)

3- "Operational Cost Analysis of Coastal Fishing Vessel", AEJ, July, (Egypt-988), Shama, M. A., (100%)

4- "An Economic Evaluation Model for the Egyptian Coastal Fishing Vessel", AEJ, July, (Egypt-1989), Shama, M. A., (100%)

5- "Investment Decisions on Coastal Long Liners", AEJ, October,. (Egypt-1989), Shama, M. A. (100%)

6- "Appraisal of Fishing Vessel Economics Using Risk Analysis", AEJ, Jan., (Egypt-1990), Shama, M. A., 100%)

7- "A Rational approach to the Determination of Principal Dimensions of Coastal Trawlers", AEJ, Jan., (Egypt-1993), Shama, M. A., Eliraki, A. M., and Atwa, K. I. (33%)

8- "A Computer Based design Model for Coastal Stern Trawlers", AEJ, Jan., (Egypt-1993), Shama, M. A., Eliraki, A. M., and Atwa, K. I. (33%)

9 - "Appraisal of Fishing Vessel Economics Using Risk Analysis", ISUMA93, April. (USA-1993), Shama, M. A., (100%)

10 - "An Integrated Rational Approach for Improving the Economics of Coastal Stern Trawlers", AEJ, April. (Egypt-1994), Shama, M. A., (100%)

# A COMPUTER-BASED DESIGN MODEL FOR COASTAL STERN TRAWLERS

**M. A. Shama**
Naval Architecture, Vice Dean,
Faculty of Eng., Alex., University, Egypt.

**A.M. Eliraki and K.I. Atwa**
Marine Engineering Department,
Alexandria University, Alexandria Egypt.

ABSTRACT

This paper is concerned with the development of a computer-based model for the design of coastal stern trawlers. The emphasis is placed on the determination of the ship's principal dimensions, selection of scantlings of hull girder, selection of main engine and propeller, selection of net and trawl winch to suit operational conditions. The importance of the determination of the optimum principal dimensions for the economic operation of fishing vessels is mentioned. A rational approach is proposed for the determination of the aggregated length between perpendiculars. The determination of the breadth, depth and draught according to different design criteria is presented. These design criteria include fish hold capacity, stability and ship motions requirements. The Bureau Verities Rule is used for the design of hull girder structural members. The engine power is calculated in both free running and towing conditions. Selection of fishing net is based on the towing force developed by the thrust of the propeller. The trawl winch characteristics are determined from the hauling speed and the net drag. All the design procedures in this paper are modeled in the form of a set of computer programs (DPD, HYDRO, SHG and PROPEL) developed for the Alexandria University, Faculty of Engineering PDP 11/70 computer. A case study of a stern trawlers operating in the Red Sea is presented to demonstrate the capabilities of the developed computer- based model and programs.

## INTRODUCTION

The Egyptian aquatic coastal resources represent an essential element of the national food resources. The rational exploitation of these resources should develop present and new coastal fishing areas and improve the national economy.

In order to rationalize the exploitation of our coastal waters, it is necessary to design and operate modern fishing vessels, properly equipped and manned.

This paper is an attempt to introducing a computer-based subsystem for the design of modern coastal stern trawlers

The proposed design procedure is based on the owner requirements which are the fishing method, type of catch, fishing time, number of crew and degree of automation and also on the characteristics of the productivity and the nature of the fishing ground.

A set of computer programs are developed and presented. This computer-based design subsystem is applied to the design of a coastal trawler to operate in the Red sea. The computer programs are based on the Alexandria University, Faculty of Engineering, PDP-11/70 computer.

## DETERMINATION OF PRINCIPAL DIMENSIONS

The proposed approach of aggregated lengths is based on the decomposition of the total length of the fishing vessel into the lengths of the different sections of the hull. The individual lengths of each section is determined according to the factors affecting the design parameters of each section. The total length of the vessel is the sum of these lengths. The breadth and the depth are determined according to the ratios of B / T and B / D, fish hold capacity, stability and ship motions requirements. The draught is determined according to the displacement equation. In this approach, the length of a stern trawler is decomposed into the lengths of the main hull sections which include the fish hold, accommodation, engine room, aft peak and fore peak. The design procedure could be summerized as follows:

i- Determination of the individual length of each hull section related to the relevant design parameters affecting it.

ii- Determination of the length between perpendiculars by summing the individual lengthes of hull sections.

iii- Determination of breadth and depth according to the following factors:

- Hull ratios (B/D, B/T)
- Fish hold capacity,
- Stability and ship motions requirements,

iv- Detrermination of draught is based on the displacement equation.

A general flow chart, Figure (1) shows the entire design procedure for the determination of principal dimensions. This approach is given in detail in reference [1].

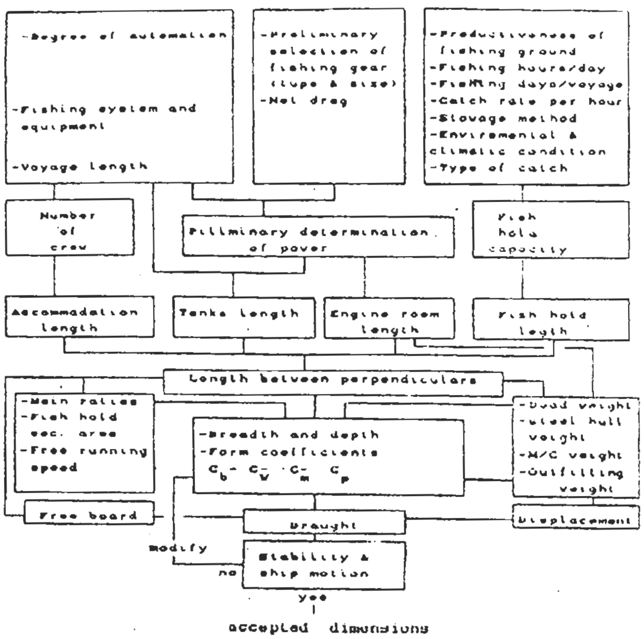


**Figure 1**. General flow chart for the determination of principal dimensions of the coastal stern trawler.

This approach, therefore, is based on a known general arrangement plan. Figure (2) (a,b) shows the two proposed general arrangement plans of a coastal stern trawlers where the accommodation is located under or above the main deck. These plans are commonly used for fishing operations in Egypt.

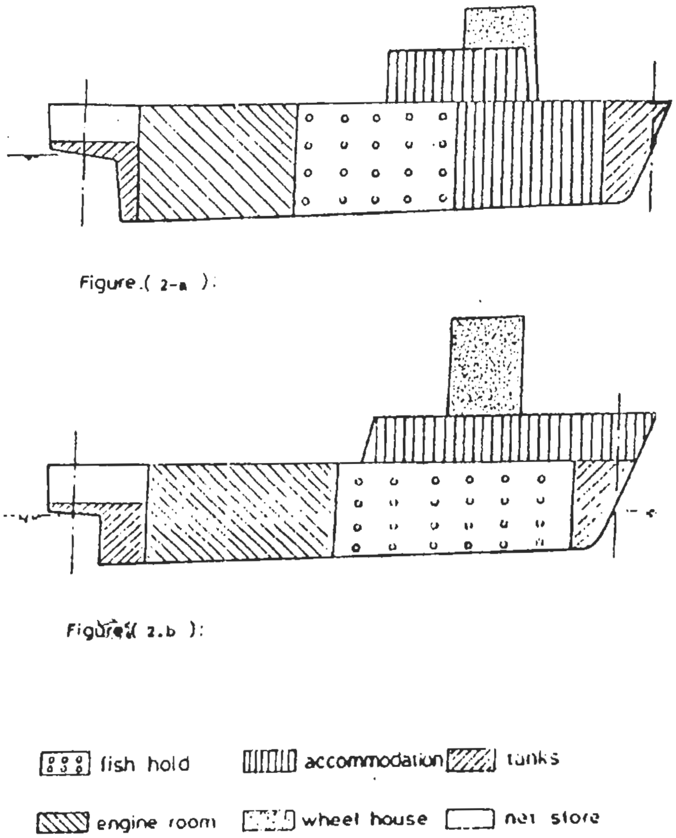


**Figure 2**. Proposed general arrangement plans for coastal fishing vessels.

These arrangements have the following advantages:

1- Locating the fish hold in the midship region gives greater capacity to the fish hold.
2- The ship has no serious trimming problem when changing from empty to loaded conditions as center of gravity of fish hold is close to the center of floatation of the vessel (nearly amidships).
3 Torsional stress and distortion of the propeller shaft is minimized as the shaft length is decreased.
4- Fish hold capacity is not reduced by the presence of a shaft tunnel.

The target now is to determine the individual length of each section in the hull for the assumed general arrangement plan. The length of each section is determined from the design parameters affecting each section as follows:

Length of fish hold depends on the amount of catch i.e. number of fishing days, fishing rate per day and the catch type [2].

Length of engine room depends on the installed engine power which must satisfy net towing requirements (towing speed and trawl net drag) [3].

Length of accommodation depends on the number of crew, fishing voyage duration, size and arrangement of furniture, etc.

Length of fore and aft parts depends on the required size of stores and amount of ballast required [3] and regulations concerning location of fore and aft peak bulkheads.

The aggregated length between perpendiculars is composed of the main hull sections lengths shown in Figure (3) (a,b) as follows:

$$\text{case a } LBP = L_{AP} + L_{ER} + L_{FH} + L_{AC} + L_{FP}$$

$$\text{case b } LBP = L_{AP} + L_{ER} + L_{FH} + L_{FP}$$

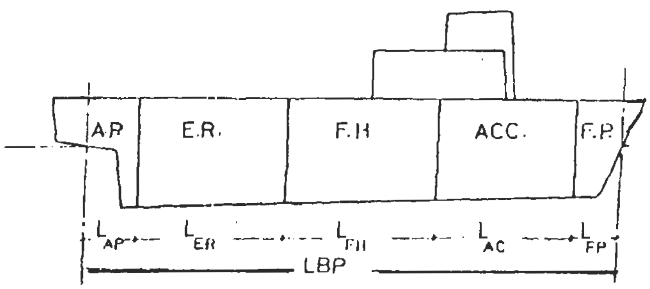


Figure:( 3. a)

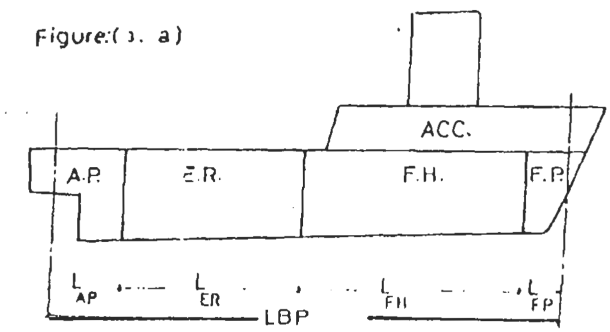


Figure.( 3. b):

**Figure 3.** Composition of length between perpendicular for proposed general arrangements of trawlers.
a- $LBP = L_{Ap} + L_{ER} + L_{FH} + L_{AC} + L_{FP}$
b- $LBP = L_{Ap} + L_{ER} + L_{FH} + L_{FP}$.

## STRUCTURAL DESIGN OF COASTAL STERN TRAWLERS

The determination of the scantlings of any structural member of a coastal fishing vessel is normally obtained from Classification socities, Rules [4].[Selection of the scantlings of hull structural members depends mainly on the general arrangement, structural configuration and the basic data of the ship.

The general arrangement of the ship has a direct effect on the determination of the scantlings of the various structural members. The main features of the general arrangement are the distribution of transverse bulkheads, ship depth, location of hatch opennings, distribution of hull sections (engine room, fish hold, accommodation, tanks ans stores) etc.

Locations of transverse bulkheads, brackets, stiffeners and spacing of transverses and longitudinals represent the main features of structural configuration of a fishing vessel (see Figure (4)).

In order to use the classification socities rules, the following data should be available:

*Ship's basic data*

The basic ship data are determined by the naval architect. They include length, breadth, depth, draught and hull form coefficients. Other data comes from the general arrangement plan of the ship such as ship depth and super structure length and height etc.

*Ship's secondary data*

These data are dependent on the basic data and the general arrangement plan and configuration of the ship. The use of the B.V. Rules for the selection of scantlings, Starting from basic data and secondary design data, the structural arrangement of the steel hull could be determined.

According to the B.V. Rules, the hull girder of a coastal trawlers is subdivided into frame spacing and scantlings zones.

The classification socities rules indicates the scantlings of the structural members as follows:

1- Thicknesses of shell plating, in mm, the thicknesses used for building are the nearest thicker standard plates.
2- Widths of some shell strakes, in cm, such as keel plate, garboard strake, sheer strake, stringer plate, lowest strake of bulkheads plating etc.
3- Sectional area of some structural members, in cm, such as center and side girders, keelsons, stern post, sole piece etc. The scantlings of these members could be detrmined from their geometry

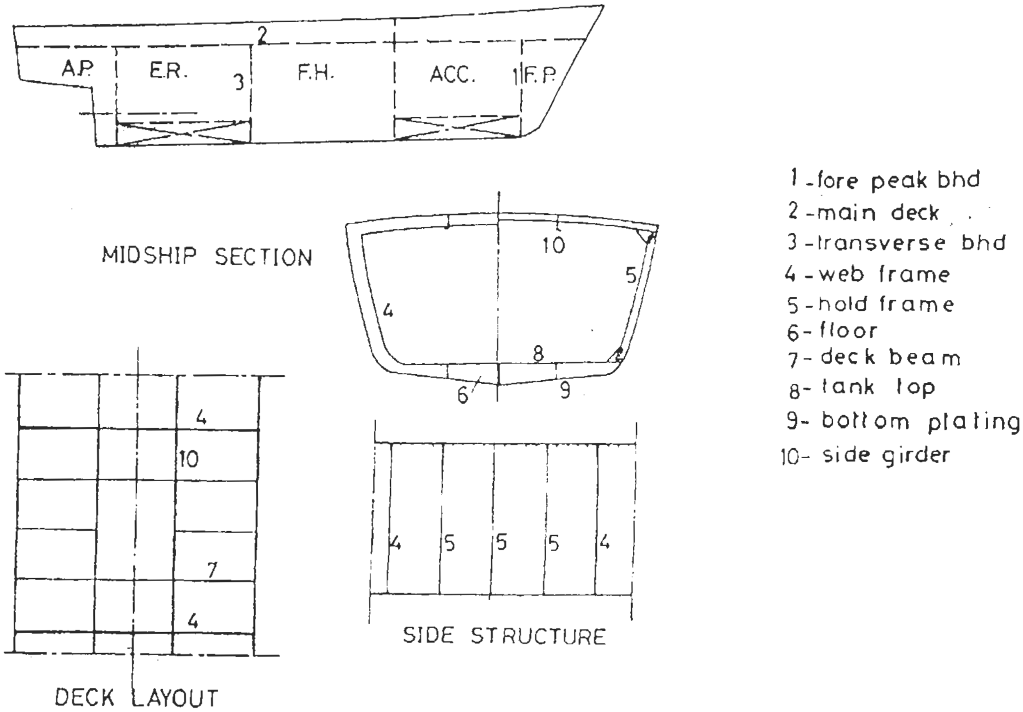


**Figure 4**. Structural configuration of the coastal fishing vessel.

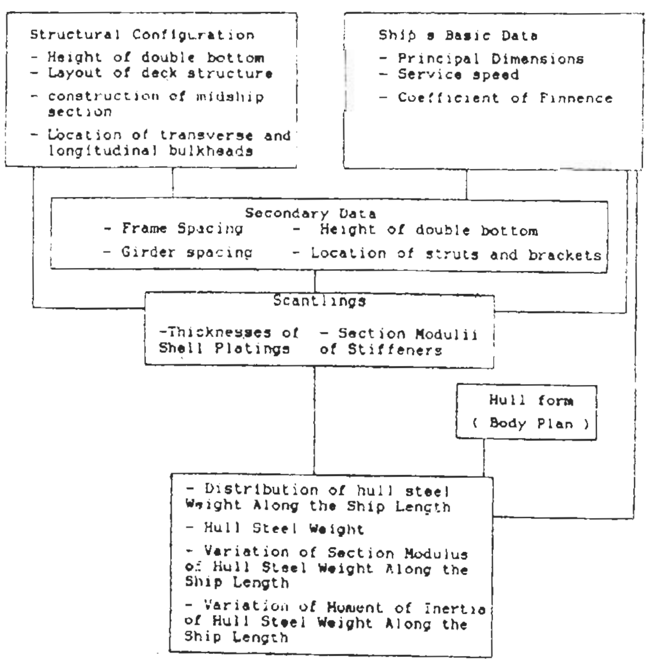


**Figure 5**. Procedure for the use of the developing (SHG) computer program.

4- Section modulus, in cm of all stiffeners (hold frames, deck beams, side and center girders, side stringer etc.) Scantlings of these stiffeners are determined as follows :

i- Using standard rolled section (L, O.B.P, flat bar)

ii- For stiffeners having larger section modulii, fabricated sections could be used. Geometry of these fabricateed sections is affected by rules requirements such as (web height / thickness) ratio, (flange area / web area) ratio etc.

A computer program (SHG) is developed to determine the scantlings of the structural members of coastal stern trawlers. The proposed procedure is illustrated in the flow chart shown in Figure (5). The developed computer programm (SHG) is also used to calculate:

- Distribution of hull steel weigh along the ship length;

$$WPM_j = \sum_{\iota=1}^{\iota=n} a_{\iota J} * \rho_{st} + \sum_{k=1}^{k=m} \frac{1}{E} * V_k * \rho_{st}$$

- Hull steel weight;

$$W_{steel} = \sum_{j=1}^{j=ns} WPM_j$$

Variation of the moment of inertia of steel hull girder;

$$MI_j = \sum_{\iota=1}^{\iota=n} + \sum_{\iota=1}^{\iota=n} a_{\iota j} y_{\iota j}^2 - \sum_{\iota=1}^{\iota=n} a_{\iota j} * y_B^2$$

Variation of section modulus of steel hull girder along the ship length;

$$SM_j = \frac{MI_j}{y_j}$$

$$y_i = \frac{\sum_{\iota=1}^{\iota=n} a_{\iota j} y_{\iota j}}{\sum_{\iota=1}^{\iota=n} a_{\iota j}}$$

where

| | |
|---|---|
| $WPM_j$ | Weight of steel hull per meter length at any station in tonne/ m, |
| $a_{\iota j}$ | Sectional area of any longitudinal structural member im $m^2$, |
| E | Frame spacing according to rules im $m^3$ |
| $V_k$ | Volume of any transverse structural member in $m^3$ |
| $\rho_{steel}$ | Density of steel in tonne |
| $W_{steel}$ | Weight of steel hull girder in tonne |
| n | Number of longitudinal structural members |
| ns | Number of stations |
| m | Number of transverse structural members |
| MI | Moment of inertia of hull girder at any station in $m^4$ |
| $y_j$ | Distance from deck or bottom to neutral axis at any station in m |
| $i_{x_{\iota j}}$ | Moment of inertia of any longitudinal structural member about, its own xx axis |
| $y_{ij}$ | Distance from any longitudinal structural member to neutral axis N-A in m |
| $y_B$ | Distance from bottom of ship to neutral axis N-A in m |
| $SM_j$ | Section modulus of steel hull girder at any station in m |

All the above mentioned data could be determined at each station along the ship length specially the midship section as ashown in Figure (6).

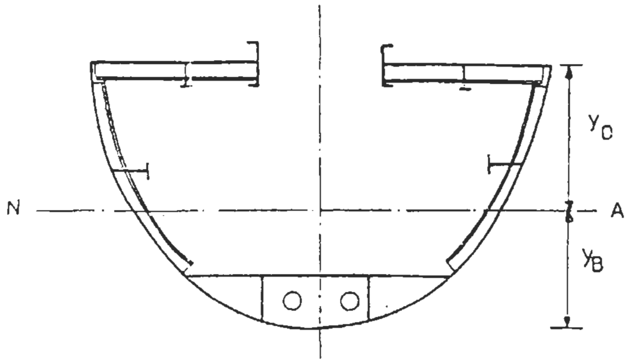


**Figure 6**. Structural configuration of mid ship section.

## MATCHING THE HULL, ENGINE, PROPELLER, NET AND THE TRAWL WINCH,

The aim of this section is to present a rational procedure for the proper selection of engine, trawl winch and the optimum propeller design to suit the operational condition of the stern trawler. In the free running condition, the engine power is required to overcome the resistance of the hull at the designed free running speed,

In the towing condition during fishing, the engine power is required to overcome both the hull resistance at towing speed and the trawl drag.

The engine selection should satisfy both free running and towing conditions.

Propeller is designed to meet the requirements of the free running condition i.e. to attain the design speed of the ship and to give the required thrust at towing speed.

In the following, the matching procedure is presented in details:

## POWERING CALCULATION

### *Free running condition*

The engine power required to operate the vessel at the required free running speed is given by the following formula [5]:

$$EHP_1 = (C_{tl} * \Delta v^3) / (325.7 * L)$$

where

| | |
|---|---|
| $C_{TL}$ | Telfers resistance coefficient [4] |
| $\Delta$ | Displacement, in tonnes |

V   Free running speed, in knots
L   Length between perpendiculars, in ft

Brake horse power of the main engine could be determined assuming a suitable value for the mechanical efficiency.

*Towing condition*

Power required for towing condition could be preliminary estimated by assuming a net size and type suitable for the intended fishing operation. This assumption is affected by the following factors :,

1- Type of catch
2- Size of catch
3- Number of crew
4- Degree of automation of the fishing gear
5- Nature of the sea bed in the fishing ground

Towing speed is ranging between 2.5 and 4.5 knots depending on the catch [6].

Trawl drag is calculated related to the towing speed and the twin surface area of the net [7] Diameter and length of the trawl warps are to be choosen according to the ship length [7].

Power required for towing is given by the following formula [3] :,

$$EHP_2 = 1.1 * V_t (R_N) / \eta_p$$

where

$V_t$   Towing speed, in Knots
$R_N$   Net drag, in kN
$\eta_p$   Propulsion efficiency

*Engine selection*

Engine selected should satisfy power required in both free running and towing conditions. Engine selection includes determination of the brake horse power, rpm and the reduction ratio. This could be achieved by means of engines characteristics given by the engine manufacturers.

*Propeller selection*

The choice of the propeller is largely governed in fishing vessels, by whether the vessel is mainly operating in free running or towing condition. Large trawlers are mainly engaged with fishing in deep water away from coasts so it is in practice reasonable to select the propeller to provide the best performance under the free running condition.

On the other hand small trawlers, below 35m, generally fish closer to home and often use gears which require considerably more power for towing than for the free running speed. Propellers for this size of trawlers are to be chosen to provide good towing performance. However it is desirable to assess all aspects of likely propeller performance and a compromise solution may be adopted.

Final selection of the trawl net could be achieved provided that its drag added to the hull resistance do not exceed the towing thrust of the propeller. Trawl winch size and power are determined according to the net hauling power at the desired hauling speed.

Figure (7) shows a flow chart illustrating the proposed algorithm for matching the hull, engine, propeller, trawl net, and the trawl winch,

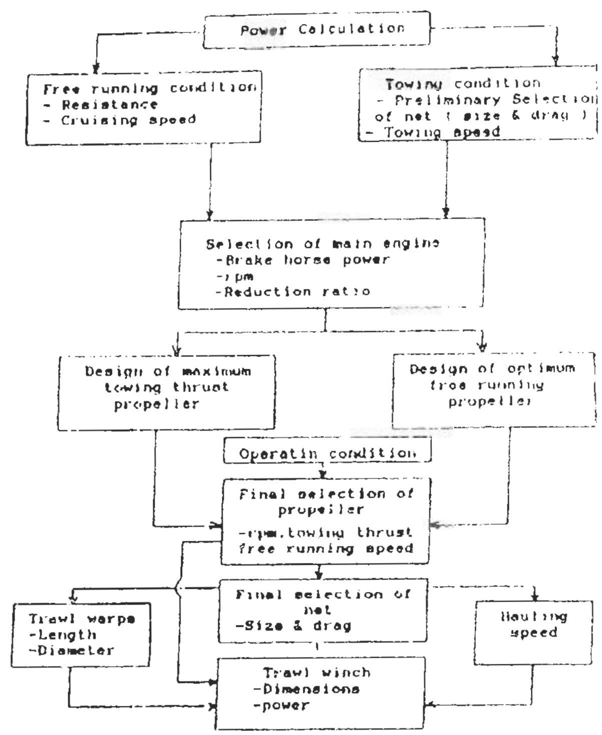


**Figure 7.** General flow chart for matching the hull engine propeller, net and the trawl winch.

## CASE STUDY

A case study is conducted to demonstrate the capability of the developed series of computer programs (DPD and SHG) for determining the principal dimensions of the fishing vessel according to the proposed approach of aggregated length and the scantlings of hull girder respectively. The latter program is used to determine :,

- Scantlings of the different hull structural members.
- Hull steel weight.
- Longitudinal position of the center of gravity of steel hull.
- Locus of the vertical position of the neutral axis above the keel along the ship length.
- Distribution of the moment of inertia of the transverse sections along the length.
- Variation of the section modulus of transverse sections along the ship' length.

The developed computer program PROPEL is used in this case study to calculate the ship resistance, to select the engine that gives the power required for a certain cruising speed, to design different propellers according to different criteria and finally to select the net size according to the maximum towing thrust of the propeller and also to determine the trawl winch characteristics (dimensions and power).

The ship's operation is assumed to be as follows:

i- The vessel is required to operate in the Red Eea and fish in front of the Somalis coasts.,

ii- The fishing time is taken about 10 days.

iii- The outgoing voyage time and the return voyage time together are 14 days.

iv- The vessel is to have its full bunker in Alexandria to cover its return voyage. ,

The input data sheet for the DPD is shown in Figure (8).

The DPD could be also used in the case of specified fish hold capacity by the owner. This is referred to by the index K as follows:

$$K = 1 \text{ Specified } V_{FH}$$

$$K = 2 \text{ Unspecified } V_{FH}$$

The output of the DPD is given in the following form:

| DATA SHEET | |
|---|---|
| DURATION | FISH DATA |
| TOV - 7 DAY | Q - 12 TON/DAY |
| TRV - 7 DAY | STOWAGE METHOD I - 3 |
| TFA - 10 DAY | FROZEN FISH SINGLE 1 |
| TYPE OF GENERAL | FROZEN FISH IN BLOCKS 2 |
| ARRANGEMENT J - 1 | FROZEN FISH FILLETS 3 |
| ACCOMMODATION | FROZEN FISH IN ICE |
| ABOVE MAIN DECK 1 | SALTED FISH 5 |
| ACCOMMODATION | CANNED FISH 6 |
| UNDER MAIN DECK 2 | FISH HOLD CAPACITY<br>K - 1 SPECIFIED<br>K - 2 UNSPECIFID |
| NCR - 15 | |
| VTRAWL - 4 KNOTS | K - 2 |

**Figure 8**. Input data for case study DPD (determination of principal dimensions).

The individual lengths of each section of the hull,

- The aggregated length between perpendiculars
- Set of principal dimensions (breadth, depth and draught) is shown in Table 1.
- The final values of breadth, depth and draught are given in Table 1. The choice of the breadth, depth and draught will be done considering that GM calculated is greater than GM min and less than GM max as shown in Figure (9). Output of DPD determination of arincipal dimensions

LBP = 29.95 m $L_{FH}$ = 12.427 m

$V_{FH}$ = 232.5 $m^3$ $L_{ER}$ = 8.244 m

BHP = 790 hp

$C_b$ = 0.499

Trawling Speed = 4. knots

Cruising Speed = 9.5 Knots

Displacement = 343 ton

$\overline{GM}$ = 0.35 m

**Table 1**. Set of principal dimensions.

| Breadth m | Depth m | Draught m | GM m | $GM_{max}$ m |
|---|---|---|---|---|
| 10.53 | 3.95 | 2.42 | 2.1 | 1.28 |
| 10.09 | 3.09 | 2.15 | 2.71 | 1.76 |
| 9.65 | 3.23 | 2.24 | 2.15 | 1.07 |
| 9.21 | 3.38 | 2.35 | 1.63 | 0.98 |
| 8.77 | 3.55 | 2.47 | 1.16 | 0.89 |
| 8.33 | 3.47 | 2.60 | 0.73 | 0.80 |
| 7.90 | 3.95 | 2.74 | 0.34 | 0.72 |
| 7.46 | 4.18 | 2.90 | -0.02 | 0.64 |
| 7.02 | 4.44 | 3.90 | -0.35 | 0.57 |

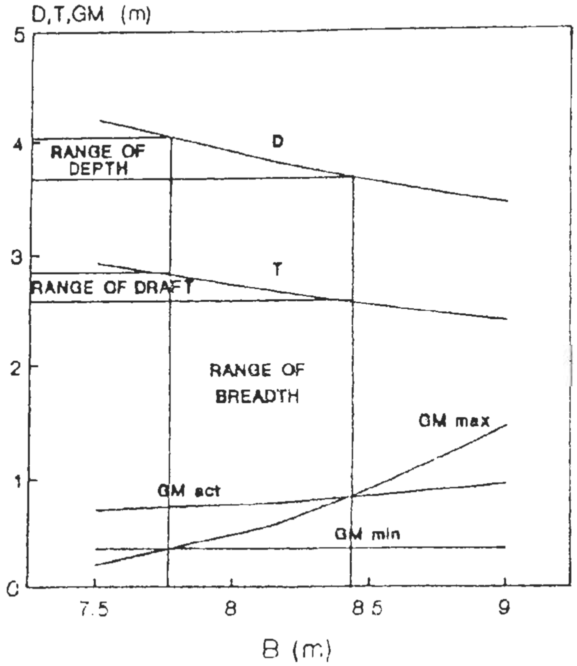


**Figure 9**. Determination of bread depth for stability and ship motion requirements.

| DATA SHEET | | | | | |
|---|---|---|---|---|---|
| L = 29.95 m | | BM = 8 m | | J = 1 | |
| DM = | 3.8 m | D = | 2.8 m | | |
| HTD = | m | LFH = | 12.42 m | | |
| LER = | 8.25 m | LAC = | 6.0 m | | |
| LAP = | 1.8 m | LFP = | 1.4 m | | |
| RV = | 0.3 m | VS = | 18. kts | DS = | 0.5 m |
| RUDARE = | 2.8 m² | BDH = | 6.0 m | PERSS = | 31 m |
| LSS = | 3.0 m | LSPST = | 9.0 m | LGS = | 4.0 m |
| X = | 9 m | L14 = | 3.23 m | | |
| L14D = | 3.2 m | B14 = | 3.4 m | | |
| S12 = | 3.6 m | L12 = | 12.15 m | | |
| L16 = | 3.23 m | S17 = | 1.94 m | | |
| L15 = | 12.15 m | L17 = | 7.68 m | | |

**Figure 10**. Input data for case study SHG (Scantlings of hull Girder).

The input data for SHG is given in the data sheet as shown in Figure (10).

The results of the SHG program are as follows:

1- Scantlings and section modulus of different structural members of the steel hull (plating, frames, girders, longitudinal and deck beams) in different sections of the hull (mid ship region, fore and aft ends, and super structure). See Tables (2,3,4,5,6).

2- Distribution of steel hull parameters, position of neutral axis, moment of inertia of continuous longitudinal members and section modulus. See Figures (11), (12)

**Table 2.**

| Thickness of shell plating midship region | |
|---|---|
| keel plate | 90 *13 |
| bar keel | 156 * 26 |
| gaboard plate | 10 |
| outer bottom plating | 9 |
| side shell plating | 9 |
| sheer strake | 9 |
| stringer plate | 9 |
| deck plating | 7 |
| inner bottom plating | 7 |
| side girder | 8 |
| center cirder | 8 |
| solid floor | 5 |

**Table 3.**

| Stiffener | Scantlings of Stiffeners | | |
|---|---|---|---|
| | Section Modulus $cm^3$ | Scantlings mm*mm*mm | Sectional AREA $cm^2$ |
| deck side girder | 2067 | 300*25*250*25 | 133.5 |
| deck beam | | or 430*17O.B.P | 107 |
| hold frame | 42 | 100*50*7 | 10.5 |
| side stringer | 44 | 100*50*7 | 10.5 |
| bhd stiffener | 880 | 200*200*20 | 79.5 |
| bhd stringer | | or300*12 o.B.P | 60.0 |
| | 23 | 70*50*6 | 8.0 |
| | 435 | 200*150*12 | 42.0 |

**Table 4.**

| Scantlings of fore end | |
|---|---|
| section modulus of collision bhd | =41 $cm^3$ |
| stiffener | =7 mm |
| thickness of collision bhd plating | =25 mm |
| thickness of bar stem | =45 $cm^2$ |
| sectional area of bar stem | =10 mm |
| thickness of plate stem | =6.5mm |
| thickness of floors | 29 $cm^2$ |
| shell plating | |
| sectional area of stringers | |

**Table 5.**

| Scantlings of aft end | |
|---|---|
| thickness of stern post | 65 mm |
| sectional area of stern post | 12 cm$^2$ |
| thickness of boss | 38 mm |
| section modulus of sole piece | 115 cm$^2$ |
| thickness of floor | 6.5 mm |
| shell plating | 6.5 mm |

**Table 6.**

| superstructure and deck house | |
|---|---|
| thickness of deck house plating | =6.5 mm |
| s/s side plating | =.5 mm |
| s/s deck plating | 7 mm |
| section modulus of s/s frames | 12 mm$^3$ |
| section modulus of deck beams | 10 cm$^3$ |
| section modulus of girders | 120 cm$^3$ |

weight of steel hull per meter length amidship =2.93 ton/m
weight of steel hull = 71 ton.
section modulus of steel hull amidship = 0.33 m$^3$ (Figure).
moment of inertia of hull amidship = 0.54 m$^4$ (Figure).

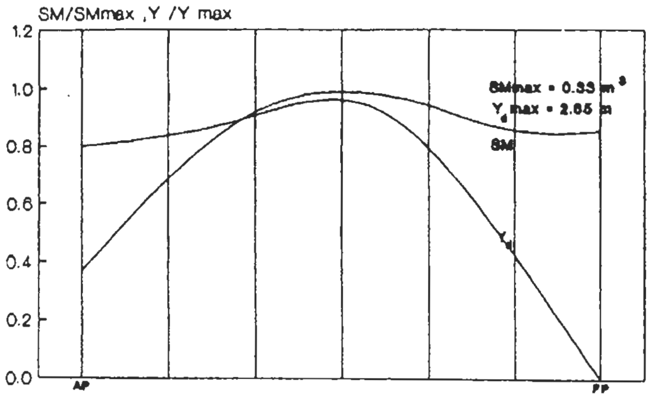


**Figure 11**. Distribution of section modulus location of neutral axes along the ship length LBP = 29.95 m.

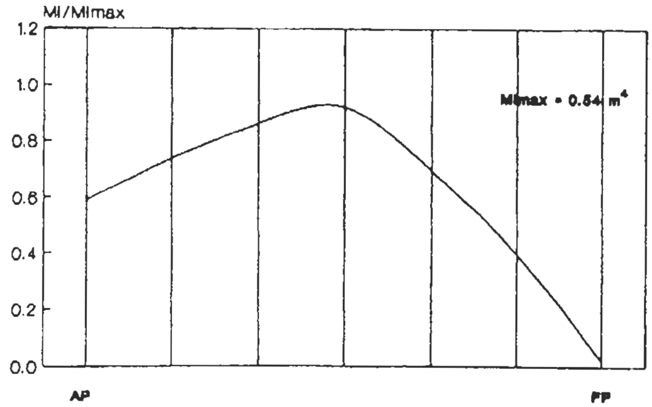


**Figure 12**. Distribution of moment of inertia along the ship length LBP = 29.95 m.

The input data for the developed computer program PROPEL are give as follows:

i- Hull form parameters (principal dimensions, LCB, $C_p$, $C_m$, $C_w$, $C_b$)
ii- Aperture dimensions.
iii- Required cruising speed

The output of this program is as follows:

1- Different free running speed and the corresponding required shaft horse power
2- The selection of the engine power according to the required free running speed.
3- Design of the propeller required for the optimum free running condition, determination of the rpm required for towing condition and the corresponding towing thrust
4- Propeller design for the maximum towing thrust and corresponding speed.

## CONCLUDING REMARKS

From the foregoing study and analysis, the following are the main conclusions:

1- Selection of the principal dimensions of the coastal stern trawlers should satisfy the dimensional constraints and the various technical and operational requirements.
2- The proposed approach for estimation of length between perpendiculars is very logical for coastal stern trawlers as the length determined from this approach is generally less than that determined from the conventional method for the same ship characteristics. ,

3- The proposed design procedure for matching among hull girder, propeller and net drag requirements, is very suitable for the selection of the appropriate values of engine power, propeller and trawl winch characteristics.
4- The computer - based design procedure could be used effectively for the design of coastal stern trawlers with minimum of basic input data.

REFERENCES

[1] M.A.Shama, A.M. Eliraki and K.I. Atua "A Rational Approach to the Determination of the Principal Dimensions of Coastal Stern Trawlers", *Due to Submission.*

[2] M.A.Shama " An Economical Evaluation Model for the Egyptian Coastal Fishing Vessel " *Alexandria Engineering Journal, Alexandria University*, Vol. 28, pp. 320-331, 1989.

[3] W. Stovhase " Aspects of Fishing Trawlers Design", *Unpublished*,

[4] Bureau Verities "Rules and Regulations for the Construction and Classification of Steel Fishing Vessels ", *Bureau Veritas*, 1982.

[5] D.J.Doust "Statistical Analysis of Resistance Data" Fishing Boats of the World: 2, *FAO*, pp. 268 - 284, 1960.

[6] J. Fayson " Design of Small Fishing Vessels" *FAO*, 1988.

[7] F.A.O." Fishing Manuals " Otter Board Design and Performance", *FAO*, Rome, 1974.