2.3 The Traditional Way to Represent the Hull Form

A ship's hull is a very complicated 3 dimensional shape. With few exceptions an equation cannot be written that fully describes the shape of a ship. Therefore, engineers have placed great emphasis on the graphical description of hull forms. Until very recently, most of this work was done by hand. Today high-speed digital computers assist the engineer with the drawings, but they are not substitutes for imagination and judgment.

Traditionally, the ship's hull form is represented graphically by a lines drawing. The lines drawing consist of projections of the intersection of the hull with a series of planes. The planes are equally spaced in each of the three dimensions. Planes in one dimension will be perpendicular to planes in the other two dimensions. We say that the sets of planes are mutually perpendicular or orthogonal planes.

The points of intersection of these planes with the hull results in a series of lines that are projected onto a single plane located on the front, top, or side of the ship. This results in three separate projections, or views, called the Body Plan, the Half-Breadth Plan, and the Sheer plan, respectively. Figure 2.2 displays the creation of these views.

Representing a 3 dimensional shape with three orthogonal plane views is a common practice in engineering. The engineer must be able to communicate an idea graphically so that it can be fabricated by a machinist or technician. In engineering terms this type of mechanical drawing is referred to as an “orthographic plate” because it contains three orthogonal graphic pictures of the object. Orthographic projections are used in all engineering fields.

To visualize how a “lines drawing” works, place the ship in an imaginary rectangular box whose sides just touch the keel and sides of the ship. The bottom, side and front of the box will serve as the basis for three orthogonal projection screens on which lines will be projected onto. The lines to be projected result from the intersection of the hull with planes that are parallel to each of the three orthogonal planes mentioned. Refer to Figure 2.2.

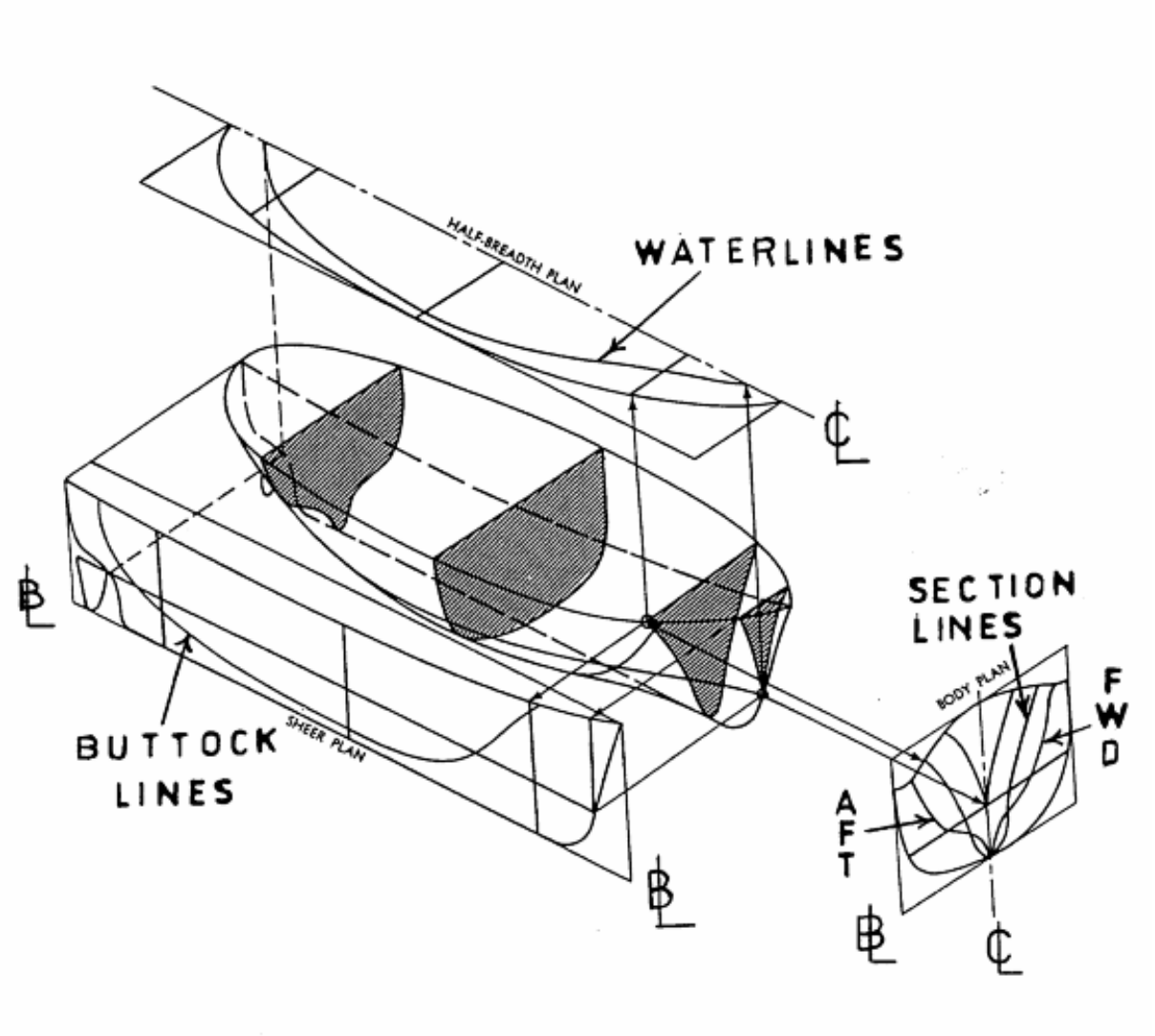

Figure 2.2 – The Projection of Lines onto 3 Orthogonal Planes

2.3.1 The Half-Breadth Plan

The bottom of the box is a reference plane called the base plane. The base plane is usually level with the keel. A series of planes parallel and above the base plane are imagined at regular intervals, usually at every foot. Each plane will intersect the ship's hull and form a line at the points of intersection. These lines are called “waterlines” and are all projected onto a single plane called the “Half Breadth Plan”. Figure 2.3 shows the creation of this plan.

Each waterline shows the true shape of the hull from the top view for some elevation above the base plane which allows this line to serve as a pattern for the construction of the ship’s framing. The grid network on the half-breadth plan is straight lines that represent the orthogonal planes containing the buttock and station lines.

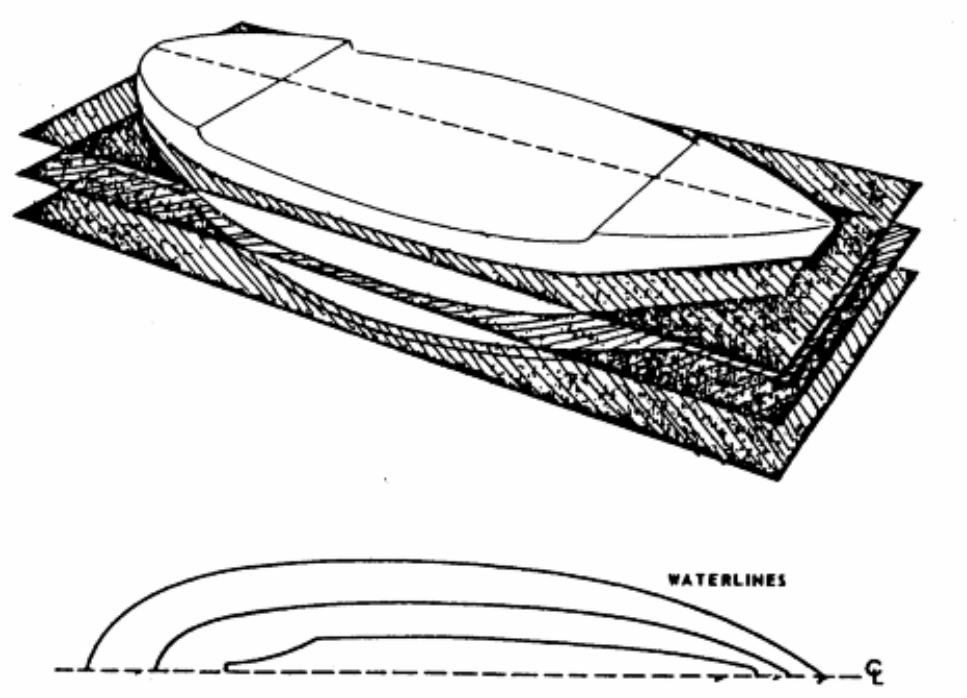

Figure 2.3 – The Half-Breadth Plan

The waterlines referred to here have nothing to do with where the ship actually floats. These waterlines are the intersection of the ship’s hull with some imaginary plane above the base plane. There will be one plane above the base plane that coincides with the normal draft of the ship, this waterline is called the “Design Water Line”. The design water line is often represented on drawings as “DWL” or “$\underline{\nabla}$”.

Since ships are symmetric about their centerline they only need be drawn for the starboard or port side, thus the name of “Half Breadth Plan”.

2.3.2 The Sheer Plan

A plane that runs from bow to stern directly through the center of the ship and parallel to the sides of the imaginary box is called the centerline plane. A series of planes parallel to one side of the centerline plane are imagined at regular intervals from the centerline. Each plane will intersect the ship's hull and form a curved line at the points of intersection. These lines are called "buttock" or "butt lines" and are all projected onto a single plane called the "Sheer Plan". Figure 2.4 shows the creation of this plan.

Each buttock line shows the true shape of the hull from the side view for some distance from the centerline of the ship. This allows them to serve as a pattern for the construction of the ship's longitudinal framing. The grid network on the sheer plan is straight lines that represent the orthogonal planes containing the station lines and waterlines.

The centerline plane shows a special butt line called the "profile" of the ship.

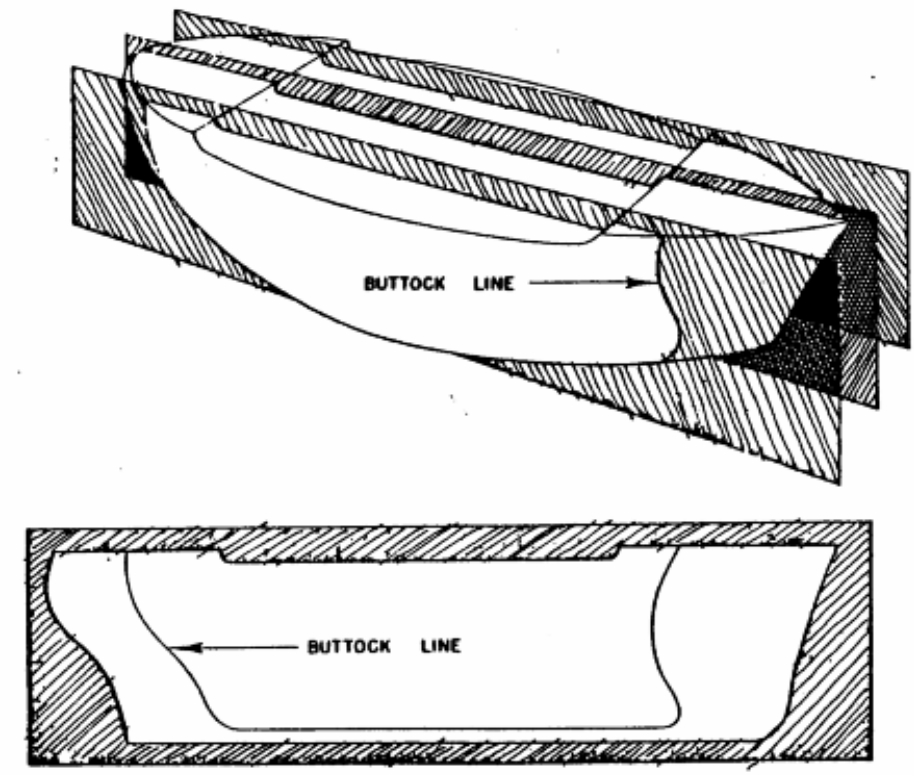

Figure 2.4 – The Sheer Plan

The sheer plan gets its name from the idea of a sheer line on a ship. The sheer line on a ship is the upward longitudinal curve of a ship's deck or bulwarks. It is the sheer line of the vessel which gives it a pleasing aesthetic quality.

2.3.3 The Body Plan

Planes parallel to the front and back of the imaginary box running port to starboard are called stations. A ship is typically divided into 11, 21, 31, or 41 evenly spaced stations. The larger the ship the more stations will be made. An odd number of stations results in an even number of equal blocks between the stations.

The first forward station at the bow is usually labeled station number zero. This forward station is called the forward perpendicular (FP). By definition the FP is located at a longitudinal position as to intersect the stem of the ship at the DWL.

The after-most station is called the after perpendicular (AP). By definition the AP is located at a longitudinal position as to intersect the stern at the DWL for ships with a transom stern or alternatively through the rudder stock of the vessel.

The station midway between the perpendiculars is called the midships station, usually represented by the ⌀ symbol. The length between perpendiculars has the symbol "Lpp". Engineers typically use the Lpp for calculations. There is also an overall ship length "LOA" that might be a more useful number to use if you were docking the ship. Figure 2.5 displays these hull form characteristics.

Each station plane will intersect the ship's hull and form a curved line at the points of intersection. These lines are called "sectional lines" and are all projected onto a single plane called the "Body Plan". Refer to Figures 2-6 and 2-7.

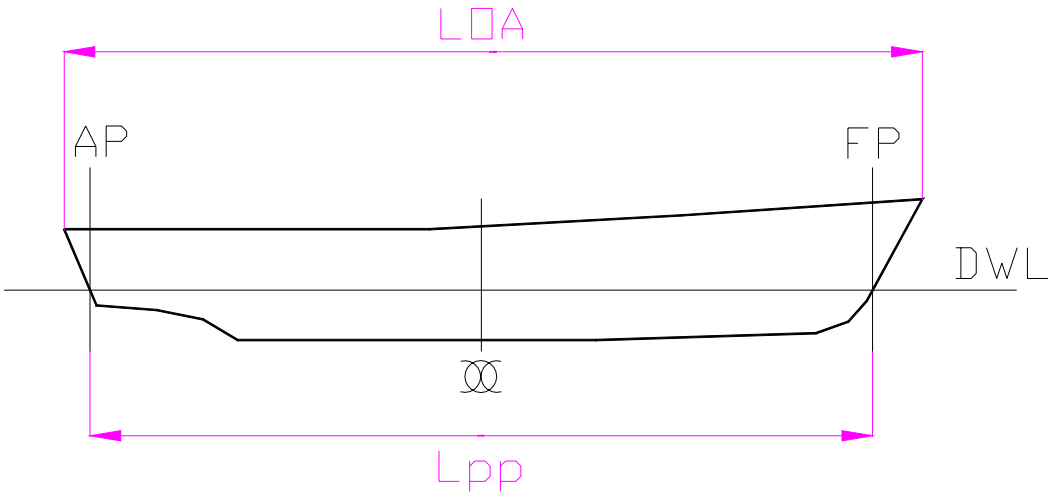

Figure 2.5 – Hull Form Nomenclature

The body plan takes advantage of the ship's symmetry. Only half of each section is drawn because the other half is identical. By convention, the sections forward of amidships are drawn on the right side, and the sections aft of amidships are drawn on the left side. The amidships section is generally shown on both sides of the body plan. The vertical line in the center separating the left and right half of the ship is called the centerline.

Each sectional line shows the true shape of the hull from the front view for some longitudinal position on the ship which allows this line to serve as a pattern for the construction of the ship's transverse framing. The grid network on the body plan is straight lines that represent the orthogonal planes containing the buttock lines and waterlines.

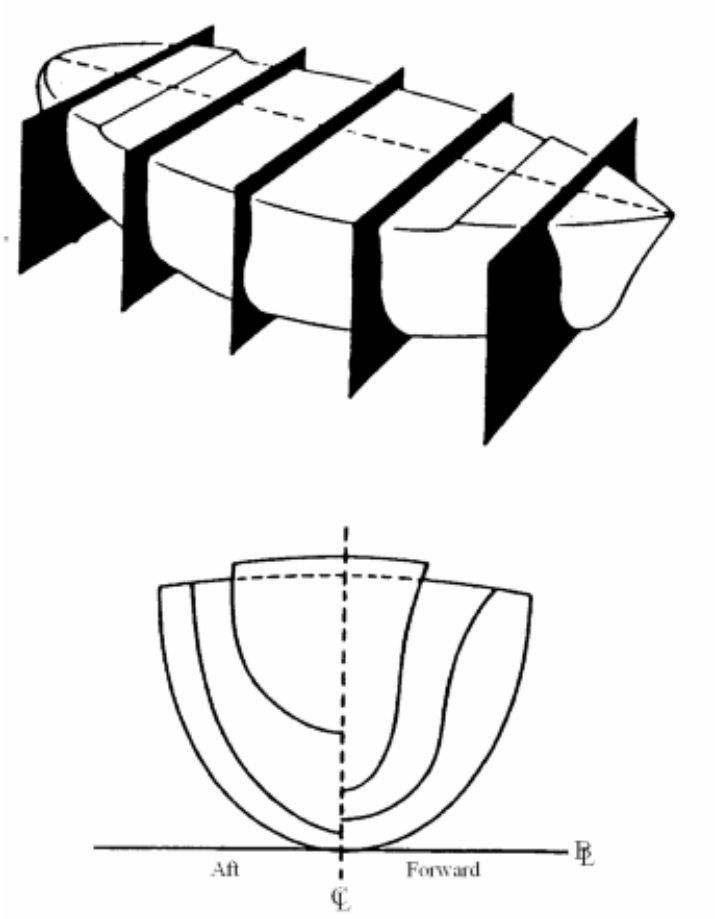

Figure 2.6 – The Body Plan

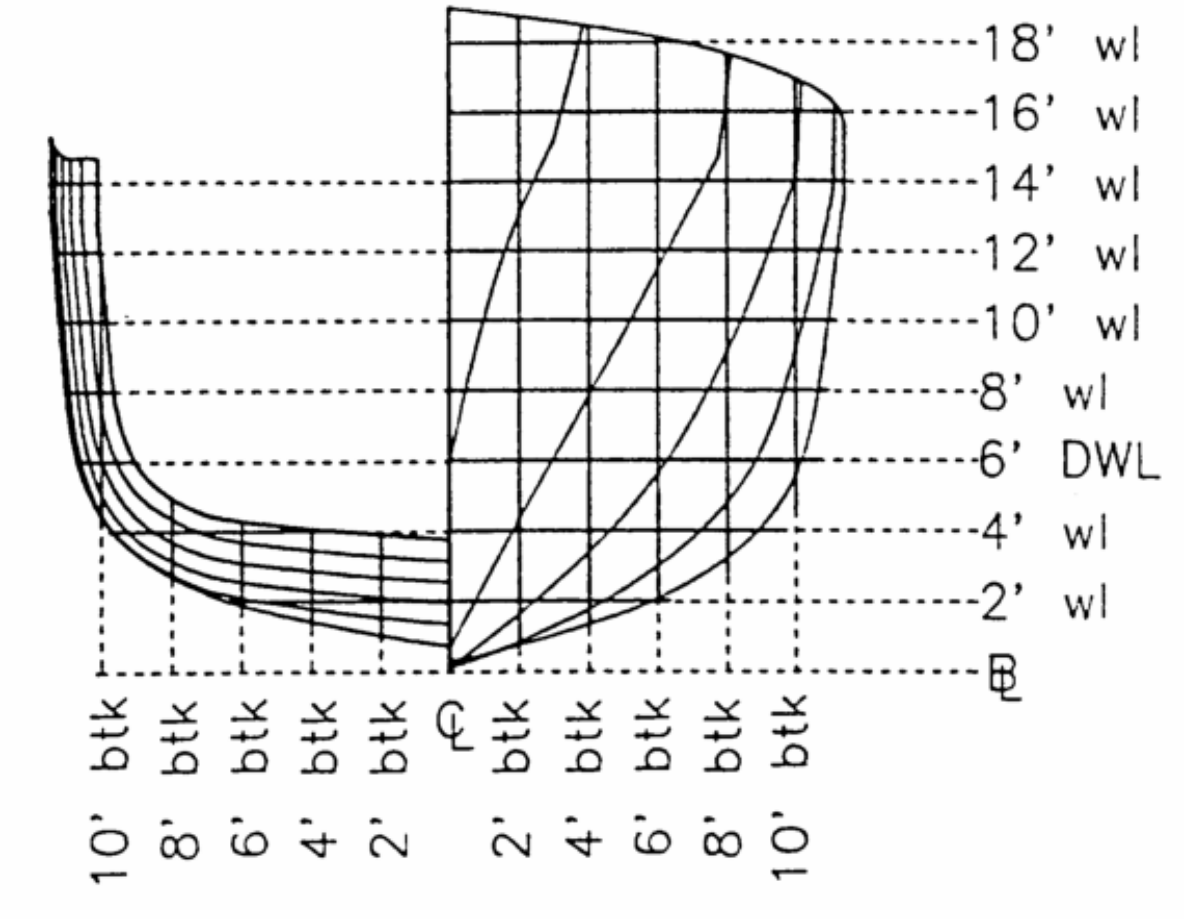

Figure 2.7a – Modified USNA Yard Patrol Craft Body Plan

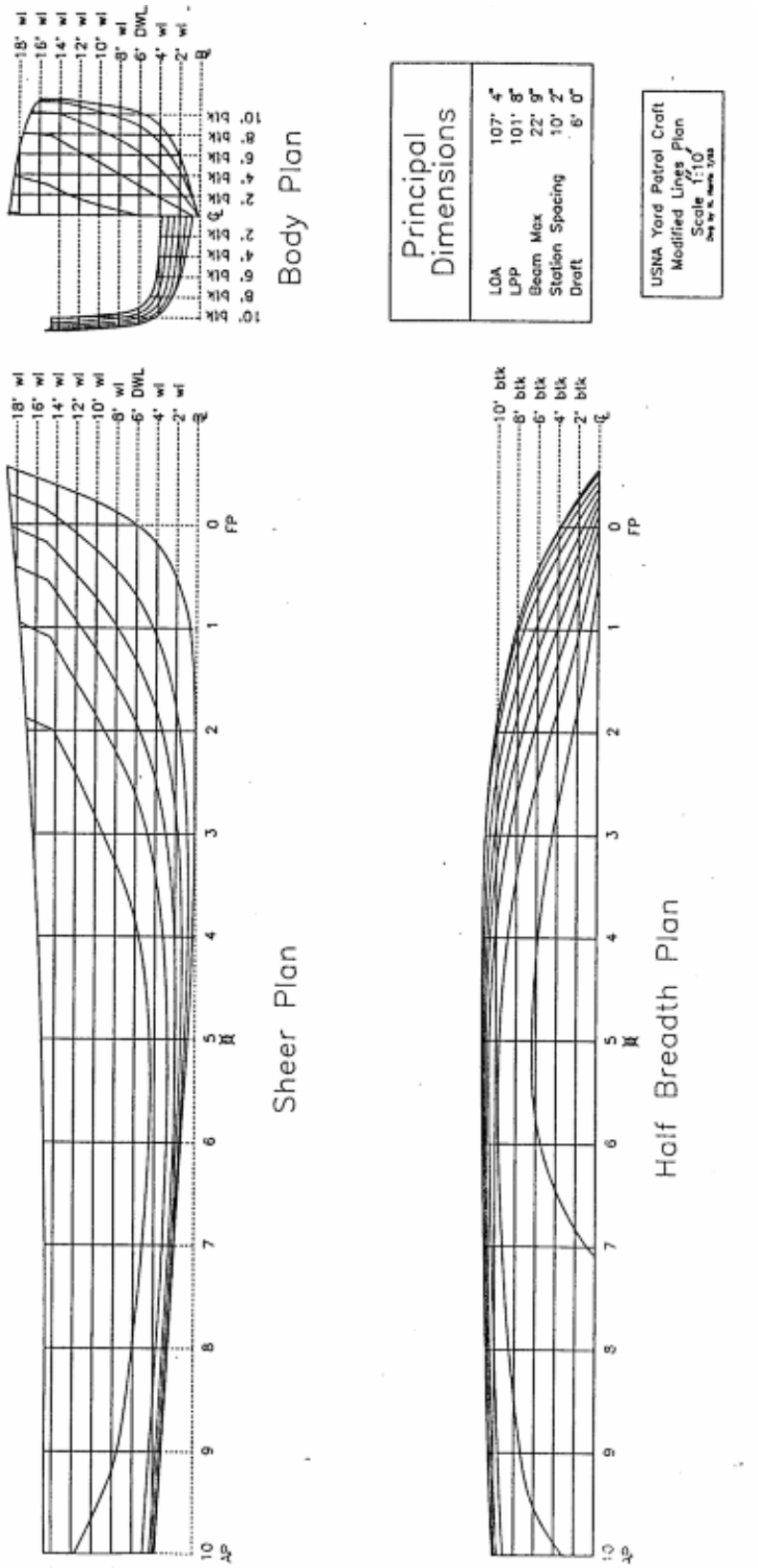

Figure 2.7b – Modified Lines Plan of the USNA Yard Patrol Craft

2.4 Table of Offsets

To calculate geometric characteristics of the hull using numerical techniques, the information on the lines drawing is converted to a numerical representation in a table called the table of offsets.

The table of offsets lists the distance from the center plane to the outline of the hull at each station and waterline. This distance is called the “offset” or “half-breadth distance”. By convention this is the “y” direction.

There is enough information in the table of offsets to produce all three plans of the lines plan. The table opposite is the table of offsets for the Naval Academy’s yard patrol craft.

You may need to use the table of offsets when you are asked to calculate one of the geometric properties of the hull such as sectional area, waterplane area, submerged volume and the longitudinal center of flotation. You will learn how to do this in the remaining portion of this chapter.

Of the 2 tables, Half-Breadths from the Centerline is the more useful as will be explained when numerical calculations are performed in the next section.

USNA YARD PATROL CRAFT - TABLE OF OFFSETS

Half-breadths from Centerline (ft)

Stations	0	1	2	3	4	5	6	7	8	9	10
Top of Bulwark	3.85	8.14	10.19	11.15	11.40	11.40	11.26	11.07	10.84	10.53	10.09
18' Waterline	3.72	-	-	-	-	-	-	-	-	-	-
16' Waterline	3.20	7.92	10.13	11.15	-	-	-	-	-	-	-
14' Waterline	2.41	7.36	9.93	11.10	11.39	11.40	11.26	11.07	10.84	10.53	10.09
12' Waterline	1.58	6.26	9.20	10.70	11.19	11.32	11.21	11.02	10.76	10.45	10.02
10' Waterline	0.97	5.19	8.39	10.21	10.93	11.17	11.05	10.84	10.59	10.27	9.84
8' Waterline	0.46	4.07	7.43	9.63	10.64	10.98	10.87	10.66	10.41	10.07	9.65
6' Waterline	0.00	2.94	6.25	8.81	10.15	10.65	10.56	10.32	9.97	9.56	9.04
4' Waterline	-	1.80	4.60	7.23	8.88	9.65	9.67	9.25	8.50	7.27	3.08
2' Waterline	-	0.72	2.44	4.44	5.85	6.39	5.46	0.80	-	-	-

Heights Above Baseline (ft)

Stations	0	1	2	3	4	5	6	7	8	9	10
Top of Bulwark	18.50	17.62	16.85	16.19	15.65	15.24	14.97	14.79	14.71	14.71	14.70
10' Buttock	-	-	14.20	9.24	5.63	4.48	4.49	5.11	6.08	7.52	11.75
8' Buttock	-	16.59	9.14	4.82	3.24	2.71	2.77	3.16	3.71	4.36	4.97
6' Buttock	-	11.51	5.65	3.00	2.07	1.88	2.10	2.55	3.10	3.69	4.30
4' Buttock	-	7.87	3.40	1.76	1.32	1.41	1.78	2.30	2.86	3.45	4.08
2' Buttock	13.09	4.36	1.63	0.82	0.73	1.02	1.53	2.10	2.68	3.27	3.91
Keel	6.00	0.66	0.10	0.09	0.28	0.71	1.34	1.95	2.54	3.14	3.76