1. **GENERAL.** Full hull and keel measurements were taken on five Shieds Class Sloops for the purpose of determining the consistency in manufacture of the hulls over time and between manufacturers. In addition to complete hull measurements, additional measurements and observations were made on hulls located in the Marblehead, Marion, and Seawanhaka fleets. In general these checks did not allow confirmation of hull numbers and therefor can be used for general information only.

2. **HULLS MEASURED.** The following hulls were measured.

2.1. #7 "Aileen" owned by Ralph Walker of fleet 4. According to Cape Cod Sipbuilding, the builder, the blue gell coat of this hull indicates it is actualy molding number 2, not 7.

2.2. #21 "Bandit" owned by Kennedy and Rundquist of fleet 5 and built by Chris Craft.

2.3. #72 "Branwen" owned by Bob Palladino of fleet 4 and built by Chris Craft.

2.4. #80 "Wizard" owned by Richard Coons of fleet 5 and built by Chris Craft.

2.5. #227 owned by Martin Moray of fleet 8 and built by Cape Cod Shipbuilding.

3. **MEASUREMENT PROCEEDURE.** Measurements of the hull were taken to determine consistency in manufacture and if possible the effects of time on the hulls themselves and on the molds. The following measurements were taken.

3.1. Deck heights at the centerline foreward and aft of the cockpit as well as deck edge heights along the cockpit were taken relative to a taught line strung between the bow and stern. The line was held above all deck fittings by the use of a .30 foot high block placed on deck foreward and aft at a pre-determined points.

3.2. Deck breadths were taken at the same points as the deck centerlines. The breadth was to the projected intersection of the deck and side of hull.

3.3. The hull profile was taken foreward and aft of the keel with the use of a transit. Positions for taking the profile points were strategicaly placed along the profile by the use of a steel tape attached to the profile and measurements taken allong the profile relative to the stem and stern. The heights to the stem/deck, and transom/deck intersections are used to "level" the boat data during final analysis.

3.4. The position of the keel was determined relative to the stem and intersection of bottom and transom aft by the use of a tape stretched along the profile. Additional measurements at the keel and rudder were also made to determine consistancy of manufacture.

3.5. Three sections through the hull were taken to determine transverse hull shape. These sections were taken by triangulation of points along the surface of the hull from a triangular frame supported from the deck. The upper cross arm of the frame was adjusted relative to the deck measurement string, leveled athwartships and suspended verticaly relative to the true horizon. The boat can be later "Leveled" based on the data taken.

3.5.1. Foreward sections were taken aproximately 2′-11" foreward of the foreward edge of the cockpit. This put the lower sections just foreward of the keel.

3.5.2. Mid-sections were taken approximately 2′-6" aft of the foreward end of the cockpit. This was approximately the middle of the keel and provided a good check on maximum keel thickness.

3.5.3. Aft sections approximately 8" foreward of the aft end of the cockpit were taken. This provided a section which intersected at the aft end of the keel below.

3.6. Measurements were taken of the keel leading edge radii at the two joints of the deadwood as well as about half way down the lead; also on the lead at the bottom of the keel at its middle, and on the rudder trailing edge.

4. **FINDINGS**. Measurement discrepancies between the above boats can be attributed to three principal factors; manufacturing errors, shape change due to age, and measurement errors.

4.1. Manufacturing errors show up primarily in the keel, rudder, and deadwood portions of the hull. These are listed below in rough decreasing order of magnitude.

4.1.1. The lead keel is molded in an iron mold. This generally leads to a well defined keel shape, although the differences between qualities of lead and the method of support during pouring can lead to differences in keel dimension which could approach 3/8" inch in length and possibly as much as 3/16" in thickness. Also the weight of the raw lead may not be too closely controlled. There probably are no good records available as to the weight of the keels poured. A final blending of the keel to the deadwood and the lower rudder gudgeon is done by eye with the result that the finished keel shape, in particular with respect to leading edge radius has probably not been well controlled.

4.1.2. The rudders are laminated in two halves and then stuck together with the result that rudder thickness is not well controlled. The thickness of the leading edge of the rudders does not seem to be too much of a problem as long as the rudder turns within the fairing plates. The trailing edges, however, seem to vary in thickness from 5/16 inch to over 1/2 inch.

4.1.3. The deadwood between keel and hull is laminated with a matched mold with the result that the leading edge radius is not always well controlled or of high quality. Fairing compound on the leading edge, as well as at the deadwood to keel and deadwood to hull interface is necessary during manufacture and, because of working of the joints, must be replaced during the life of the boat. There is room to play with this fairing by both builders and owners. It is a measurement item which should be controlled in the future.

4.1.4. The deadwood between lead keel and the bottom of the boat is a separate piece with the keel bolted through to the bottom of the boat. There is bedding compound in these joints to take up fit problems and if the depth of the lead keel is not controlled well, there is the possibility of a considerable error in hull depth. The sampling of hulls taken indicates a tollerance of only +/- 3/8 inch which is very good. This does not mean that there aren't boats as much as +/- 3/4 inch in service.

4.1.5. The looseness of the deadwood fit causes fore and aft keel placement problems, Maintaining the straightness of the assembly at the rudder tends to hold the location of the lower aft edge of the keel well but a tollerance of +/- 3/8" has been found. The length of the rudder cutout has been controlled to within 1/16 inch in the sampling taken. The bottom leading edge of the keel, however, is more likely to float than the trailing edge, although the tollerances of this point have been about the same as the trailing edge.

4.1.6. There are two distinctly different types of lower gudgeon installed on the keels, the original Cape Cod gudgeon, and the modified Chris Craft version. A great number of the Chris Craft gudgeons were drilled off center with the result that many rudders are displaced to the port side of the boat at the bottom. Boats #21,72 and 80 are examples. The result is that the centering of the metal fairing to the rudder is not always the best on many boats.

4.1.7. Hull measurements on the main hull are in good agreement between boats and the profiles appear to be consistent. The length overall varies about +/- 3/8" maximum, which is good for a boat of this size. The hull and deck are bonded in a matched mold system which, provided the molds are properly supported, will give good and repeatable results in hull shape.

4.1.8. The relative position of the cockpit between the bow and stern is accurate within +/- 1/8" of mean length. This is due to the manufacture in the matched molds. The differences in the molded cockpit lengths are within measurement tolerances and therefor could be considered as part of the hull shape definition more than the stem or stern.

4.2. Changes in the shape of Shields Class Sloops which can be attributed to age are listed below in order of significance.

4.2.1. A chronic problem with the Shields has been at the foreward and aft support poppets used in winter storage, typicaly located just foreward and aft of the keel, and about 2 feet off centerline. More or less permanant indentations in the hull laminate are noted in these areas and can be of the magnitude of 3/8 inches out of fair with the rest of the hull.

4.2.2. There seems to be a tendency of the deck centerline to be lower, relative to the sheer on older boats, than on new. This is case of the deck sagging under its own weight and is not severe (An order of magnitude of 1/8" to 1/4" at most.

4.3. Measurement Errors. The following is an estimate of the effect of measurement error on this report.

4.3.1. The instruments used in the generation of this study have been checked for dimensional accuracy. Tapes used in overall length are accurate within 1/8 inch over 30 feet and folding rules, though not as accurate, have had the lengths corrected in the computer analysis. The transit, used as a level only, is accurate to within 1/8 inch in this study. The taught string used for the deck line, had measurable but repeatable catenary, and has been corrected for in the final analysis.

4.3.2. Transcription errors pose the greatest threat to the accuracy of any study. The use of redundant measurements where possible has helped eliminate most transcription errors.

4.3.3. Some dimensions, such as the position of the lower leading edge of the keel are taken to projected points, and therfor are subject to interpretation. Whereas most measurements are accurate to within 1/8", these interpolated points will have an accuracy more in the order of 1/4". Radii such as on the leading and bottom edges of the keel were estimated through interpretation of tangents and thus also have an limited accuracy. These can only be truely checked with a dedicated jig.

5. **RECOMMENDED ADDITIONAL STUDIES**. Additional studies should be performed by the Class to get a larger sampling of the following items in order to close potential loopholes. A minimum sampling of 10% of the actively raced boats would be minimum.

5.1. A group of leading edge templates should be made up to sample leading edge radii at the top and bottom of the deadwood, and the maximum radius in the lead. Templates with an included arc angle of about 120 degrees should be used. The radii of the above 5 boat sampling as well as other scattered boats indicated that the radius at the top and bottom of the deadwood is about 1/4 to 3/8 inch while the maximum radius on the lead is 3/8 inch to 5/8. A large leading edge radius at the deadwood could give significant performance gains.

5.2. A minumum rudder trailing edge thickness should be set. The current sampling indicated a molded thickness of 3/8 to over 1/2 inch. The condition of the trailing edge (rounded or squared) might also be specified. It would appear that some boats but not those in the above list, may have had the trailing edge thicknesses reduced through grinding.

5.3. A maximum keel thickness should be determined, as well as a minimum. A sampling of this dimension is needed to locate those who might be fiddling with their keels. A bare lead keel piece from a recent pour would be most helpful in determining what limits might have been set in normal manufacture. (Say the mold dimension less shrink +/- 1/8 inch.)

5.4. A simple chain girth taken with a tape wrapped rail to rail around the keel some point aft of the foreward cockpit edge and foreward of the aft edge of the keel would prove effective in determining and controling draft.

5.5. A maximum and minimum rudder fore and aft dimension should be set, or a template made.

6. **ADDITIONS TO SPECIFICATIONS** In addition to specifications regarding the above measurements, the following additions should be considered.

6.1. Addition of filler material above that needed to blend in the rudder fairing strips to the deadwood is not allowed.

6.2. Rudder fairing strips may not be moved from the original point of manufacture for the purpose of closing off the slot at the leading edge of the rudder, nor may the slot be filled with any substance for the same porpose.

6.3. To maintain quality between boats, the gap between the top of the rudder and hull may be closed to within 1/16 inch by the addition of filler to the top of the rudder.

6.4. Removal of lead from the keel as originaly manufactured is prohibited. Addition of lead is also prohibited.

6.5. Fairing compounds on the keel shall be limited to a maximum thickness of 1/8" except where grounding or like damage has been incurred.

6.6. The main boom, including all blocks, bails, fittings and outhaul, but excluding sheets and vang assembly, shall have a minumum tip weight of __________ measured at the foreward edge of the sail control band, and supported at the goosneck.

7. **SUGGESTED AMENDMENTS TO THE SPECIFICATIONS**. The following amendments are suggested based on the rules, Section III dated 7/80.

7.1. Change ";" to "plus one U.S. Coast Guard approved throwable such as a cushion;" at section 7.(b)

7.2. Delete the term "sewed" from section 8.(b) and 8.(c). This can save the Class a few dollars.

7.3. The windows in sections 9.(g) and 10.(b) should be limited in area and quantity. This will prevent the see-thru mylar sail with cloth corner patches.

8. **CONCLUSION** Hull dimensions of the Shields Class Sloop have been held closely relative to other classes of similar size such as the Etchells, Soling and Star. This is despite the lask of close controls by the Class itself during manufacture. Fortunately the builders did not have a desire to build a "better" Shields. More surprising is the apparent lack of effort by owners to "puff" up their boats to make them faster. The prohibition of "puffing" in other classes has not prevented the practice and with changing attitudes about sailing, it will not be long before it happens to the Shields. The leading and trailing edge of the Shields keel is the prime candidate for attack by the speed shop and limits must be imposed soon. The idea that limits might be imposed will not be a deterent for long.