AD-A173 481 SEAKEEPING AND MANEUVERING ASSESSMENT OF SWATH AGOR 23 CONFIGURATIONS(U) DAVID W TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER BET K K MCCREIGHT ET AL 1/1

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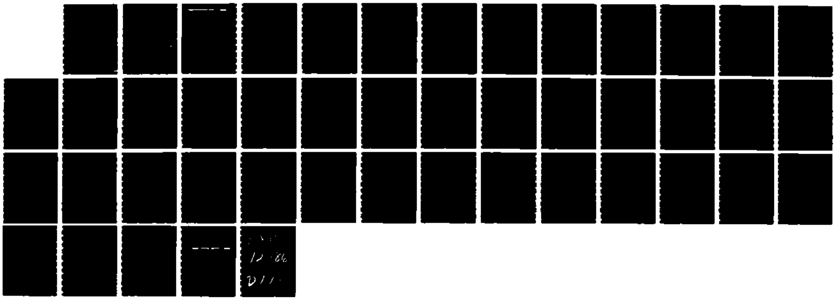

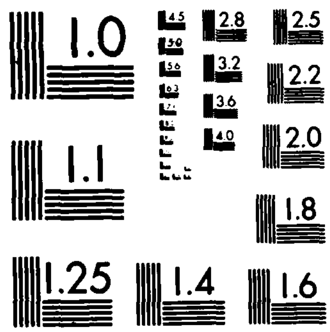

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David W. Taylor Naval Ship Research and Development Center

Bethesda, MD 20084-5000

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SHIP PERFORMANCE DEPARTMENT

SEAKEEPING AND MANEUVERING ASSESSMENT OF SWATH AGOR 23 CONFIGURATIONS

by

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R. Thomas Waters

DTNSRDC/SPD 1198-01 SEAKEEPING AND MANEUVERING ASSESSMENT OF SWATH AGOR 23 CONFIGURATIONS

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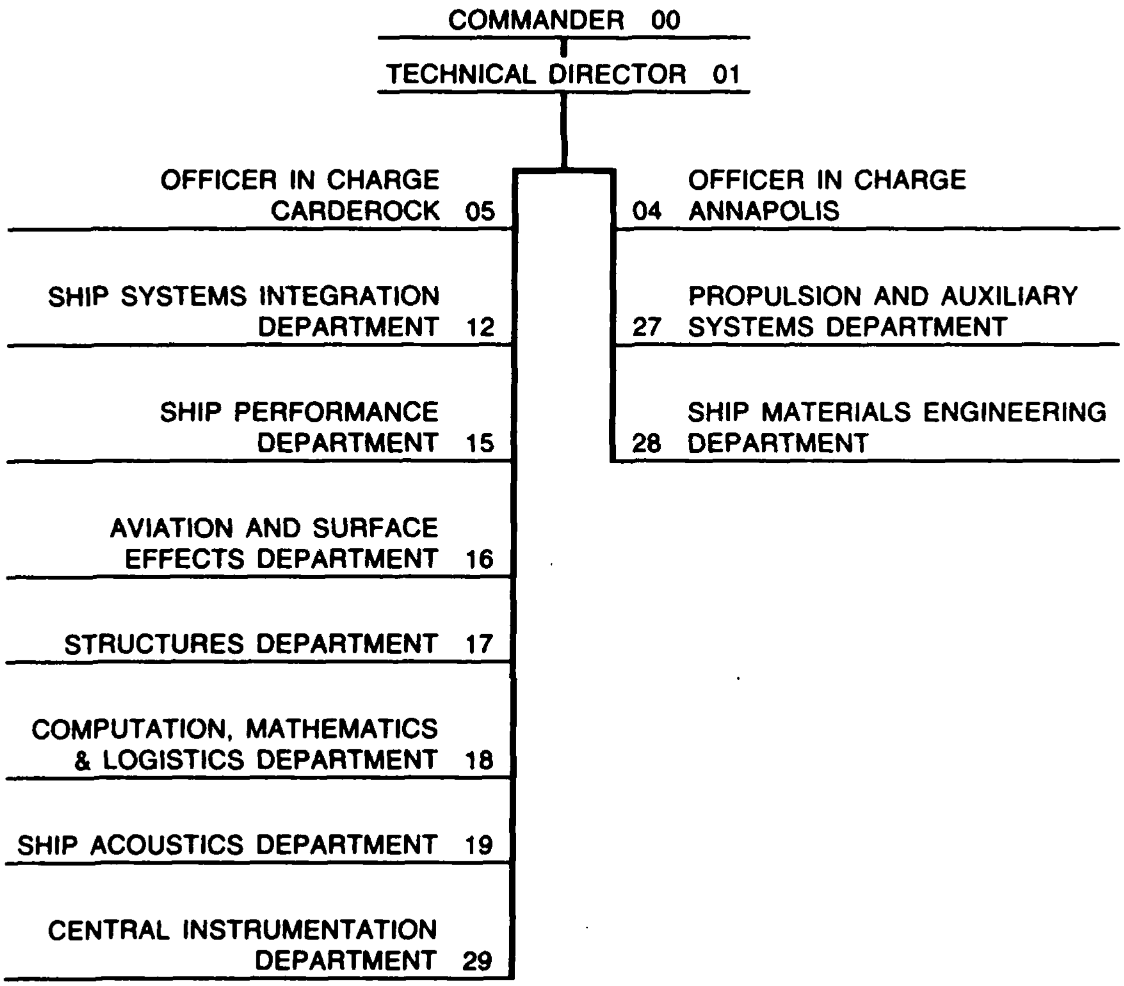

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The Naval Sea Systems Command (NAVSEA) tasked the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) to investigate the seaworthiness of designs for the AGOR 23, an oceanographic research vessel. The goal was to see if designs which were within cost constraints could also meet the Operational Requirements for seakeeping and station keeping. A series of three similar designs, with different displacements, was considered. The effect of hull form modifications on seaworthiness was investigated. The seaworthiness of an additional small displacement design was also evaluated. For this design, thrusters which met station keeping requirements were chosen.

Four SWATH designs considered in this investigation meet the seakeeping Operational Requirements. Two with similar displacements differ in design. One has a large (15.29 meters) longitudinal metacentric height (GM_L) and inactive stabilizing fins and the other has a smaller (7.67 meters) GM_L with active control for the stabilizers. Waterplane area, strut length, and lower hull length also differ.

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ABSTRACT

The Naval Sea Systems Command (NAVSEA) tasked the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) to investigate the seaworthiness of designs for the AGOR 23, an oceanographic research vessel. The goal was to see if designs which were within cost constraints could also meet the Operational Requirements for seakeeping and station keeping. A series of three similar designs with different displacements was considered. The effect of hull form modifications on seaworthiness was investigated. The seaworthiness of an additional small displacement design was also evaluated. For this design, thrusters which met station keeping requirements were chosen.

Four SWATH designs considered in this investigation meet the seakeeping Operational Requirements. Two with similar displacements differ in design. One has a large (15.29 meters) longitudinal metacentric height (GM_L) and inactive stabilizing fins and the other has a smaller (7.67 meters) GM_L with active control for the stabilizers. Waterplane area, strut length, and lower hull length also differ.

ADMINISTRATIVE INFORMATION

This project was sponsored by the Naval Sea Systems Command. Funding was carried out under Work Unit 1-1561-815.

INTRODUCTION

NAVSEA is evaluating designs for the AGOR 23, a new class of oceanographic research vessels. Monohull and SWATH designs are being considered. During 1985, a set of Tentative Operational Requirements (TOR) was developed and SWATH and monohull configurations were designed by NAVSEA. The David W. Taylor Naval Ship Research and Development Center (DTNSRDC) was tasked to assess the seaworthiness of potential designs and to make hull form modification recommendations. The seakeeping requirements were demanding: the goal was that the hull form could safely transit at 15 knots through a Sea State 6 and that scientific equipment could be launched and recovered at all headings through Sea State 6. The seakeeping characteristics of SWATH[1*] and

*A complete list of references is given on page 10.

monohull[2] designs were investigated by DTNSRDC.

Although the TOR could be met by either hull form type, the estimated construction costs of both designs were too high. Consequently, a new phase of the effort was initiated in 1986. In this effort, the design was to be cost driven rather than requirement driven. Reduced Operational Requirements (OR) were developed for the AGOR 23.

The reduced Operational Requirements for seakeeping state that an acceptable hull form must safely transit through Sea State 4 at all headings at 15 knots, transit at 6 to 10 knots at best heading through Sea State 6, and launch and recover at best heading through Sea State 5. During the course of this investigation, the transit speed was decreased from 15 to 12 knots.

The OR also requires that the hull form maintain maneuverability and keep station within a 91.4 meter (300 foot) watch circle at best heading through Sea State 5, with a 2 knot current and a 27 knot wind.

DTNSRDC was tasked to assess the seakeeping and maneuvering characteristics of the SWATH and monohull point designs. This report presents results for the assessment of the seakeeping and maneuvering characteristics of the SWATH designs.

APPROACH

The approach utilized in this study is identical to that described in Reference 1. Briefly, the computer program SSEP (SWATH Seakeeping Evaluation Program) is used to assess the seaworthiness of candidate hull forms in short crested seas. The geometric and inertial characteristics of a hull, parameters which relate to stabilizing fin selection, seakeeping criteria which describe when performance would be degraded, and a chosen geographical season and location must be defined. Then, the ability of a SWATH hull form to perform a mission can be assessed.

NAVSEA provided DTNSRDC with several SWATH configurations. First, they provided a series of hull forms which were similar in design but which varied in displacement. As noted above, cost was a major driving consideration in this study. At the beginning of this study, estimated costs were not known. Consequently, NAVSEA provided DTNSRDC with this series so that when the costs had been estimated, the hull form with the largest affordable displacement could be utilized. The seaworthiness of the three hull forms in this series was evaluated. The longitudinal centers of flotation and buoyancy were aligned and the waterplane areas were increased. The stabilizing fins were inactive.

Next, a design which was similar to the TAGOS-19 and which differed from the first series of designs in many respects was evaluated. An active control system was designed for the stabilizing fins. Thrusters were sized so that the configuration would meet the station keeping OR. Maneuvering characteristics were assessed. These evaluations will be described below.

FIRST DESIGN

NAVSEA provided DTNSRDC with three hull forms which were similar in design but varied in displacement. As will be described below, various modifications to the original designs were made. For the seakeeping assessments used in these early investigations, the "transit" seakeeping criteria set was used. More detailed seakeeping assessments were carried out for the final configurations. The seakeeping criteria are listed in Table 1.

Baseline Hull Forms

The initial baseline hull forms had inadequate displacement, given the weight estimates. Consequently, the displacements were increased. The increase was accomplished for each hull form by fixing the draft and increasing the maximum strut thickness and the lower hull axis by an appropriate factor. Strut length and lower hull length were not changed. The required displacements and drafts specified by NAVSEA are given in Table 2. These values were retained throughout this study. These configurations were denoted AGOR, AGORRED, and AGORRED2.

The separation distance between hulls was determined by taking the beam at the waterline specified for each original design and calculating a corresponding centerline to centerline separation for each design. The separation distances for each displacement were then used as constants throughout the hull form modification process described below. Minor changes in hull form separation which would result from a fixed beam (rather than a fixed hull form separation) would not notably affect ship responses.

Seakeeping Assessment of Baseline Hull Forms

Inactive horizontal stabilizing fins were designed for each hull form. The total fin area is the SWATH 6A fin area, scaled by the ratio of the displacements to the two-thirds power. A fin design algorithm[3] which is incorporated in SSEP was utilized in selecting fins. This algorithm was used to select fins which would provide vertical plane stability up to 12 knots and which would best reduce motions, according to a weighted linear expression. Active control of the stabilizing fins was excluded from consideration.

In Table 3 some characteristics of the original AGORRED2 are given. In Figure 1 the Limiting Significant Wave Heights (LSWHs) for this appended hull form are presented as a function of wave heading for three ship speeds. A LSWH is the largest significant wave height at which none of the seakeeping criteria are exceeded at a particular ship speed and relative wave heading (i.e. the larger the LSWH, the better the ship's performance).[4] For each significant wave height, only spectra with modal periods which might occur are considered. These results and others in the report are for general North Atlantic wave spectra statistics for the winter (December, January, and February). Reference 4 provides a more complete discussion of the seakeeping assessment methodology applied here. As can be seen, the OR was not met at any of the speeds of interest. The other two hull forms with larger displacements were evaluated. The results were virtually identical to these. This is not surprising since important characteristics of the three hull forms are similar.

Strut Relocation

For the original hull forms, the longitudinal centers of flotation (LCF) and buoyancy (LCB) were not coincident. In an attempt to improve seakeeping, the strut was relocated so that the LCF and LCB were aligned. NAVSEA indicated that this shift would not impact the design. Figure 2 presents the LSWHs for this modified configuration. Comparison of Figures 1 and 2 indicates that the LSWHs are increased significantly by this modification. However, the requirement that the ship safely transit at all headings through Sea State 4 was not quite met at 12 knots by either configuration.

Waterplane Area Investigation

For the baseline AGX SWATH design[1], the LSWHs were unacceptably low between following and beam seas at low speeds. For the modified AGOR 23 baseline hull forms, the converse problem existed: seakeeping assessments indicate that the low speed performance was acceptable, but that high speed performance was not. The AGX investigation showed that decreasing the waterplane area resulted in increased LSWHs at low speed and decreased LSWHs at 15 knots, and that automatic control of the stabilizers resulted in acceptable 15 knot performance.

Consequently, the effect of increasing the strut waterplane area on operability was investigated. Due to the similarity among the three designs and funding limitations, only the AGORRED2 with the LCB and LCF aligned was investigated. This configuration was chosen since it was expected that the smaller displacement would be chosen due to cost constraints. The increase in waterplane area was accomplished by increasing the maximum strut thickness by 15 percent and by 25 percent. An elliptical nose and parabolic tail on the strut were retained.

The increase in strut thickness caused the displacement to increase. To compensate for this, the lower hull two-dimensional cross sections were uniformly decreased. The required draft was retained by adjusting the strut draft to compensate for the changes in the lower hull axis. Throughout this process the distance from the bottom of the cross structure to the calm water line remained constant.

Figure 3 shows the effect of increasing waterplane area on LSWH for various speeds. An increase of 15 percent in the strut thickness did not adequately improve performance at 12 knots in beam to following seas, but a 25 percent increase was adequate. At some relative wave headings the 25 percent increase resulted in a hull form which minimally met the OR. Lower speed performance was degraded somewhat but the OR was still met.

Seakeeping Assessment of Final Configurations

As noted, the original three hull forms and the initial set of seakeeping results were similar. Consequently, the strut thicknesses of the other two hull forms were increased 25 percent. Characteristics of the resultant hull forms are given in Table 4. Descriptions of these hull forms in the form used in SWATY (the NAVSEA SWATH design computer program) are given in Tables 5 through 7. Characteristics of the stabilizing fins for the three hull forms are given in Table 8. It should be noted that the transverse metacentric heights (GM_T) are large. The effect of this on maneuverability would require investigation.

The ability of these final configurations to meet the OR for required missions was investigated. The seakeeping criteria used for these missions are given in Table 1. Values of LSWH as a function of relative wave heading are given in Figures 4 through 9 for launch and recovery (represented by the"on station" criteria) at zero speed, and for transiting at 6, 9, and 12 knots. These seakeeping assessments address the seakeeping OR. Sea state demarcations are indicated. LSWH results using the wave spectra statistics the entire year are virtually identical to these. The predictions indicate that all three of the modified hull forms would meet the requirements.

In addition, LSWHs for "on station" (0 knots), "operating" (6 knots), and "transit" (12 knots) are given in Figures 10 through 12. In the placement of the crane boom tip, it was assumed that the deck would be flush with the outside of the strut at its thickest point. For these criteria sets, the Percent Time of Operation (PTO) for each of these criteria sets with all relative wave headings assumed to be equally probable are given in Figures 13-15. The Percent Time of Operation is calculated by summing the probabilities of occurrence of wave spectra for a particular location and season for which operability is not degraded[4].

SECOND DESIGN

Following the investigation described above, NAVSEA provided DTNSRDC with an entirely new hull form. This design is similar to the T-AGOS 19 Contract Design. Since a preliminary cost analysis had been completed, an affordable displacement had been defined. For this design, assumptions regarding the stabilizers differed from the ones used for the first series of designs. The stabilizers could be activated and were canted with respect to the calm water line. The canted stabilizers in combination with the body generate a side force which eliminates the need for separate conventional rudders.

The characteristics of this hull form, denoted AGOR2, are given in Table 9. Characteristics of the stabilizing fins which were selected are given in Table 10. An initial investigation indicated that the performance of this hull form with inactive stabilizers would not meet the seakeeping OR.

Waterplane Area Investigation

An investigation of the effect of waterplane area on performance was undertaken. It was found that an increase of 25 or even 35 percent of the waterplane area had virtually no effect on the LSWHs. Comparison of Table 4 and Table 9 shows that the AGORRED2 and AGOR2 have similar displacements but differ in a number of other respects. Most notably, the lengths of the lower hull and strut differ. Since the AGOR2 strut is shorter than the AGORRED2 strut, equal increases in strut thickness result in smaller increases in the longitudinal metacentric height (GM_L) for the AGOR2 than the AGORRED2. Clearly, increasing the strut thickness is not a solution to the unacceptably low seakeeping performance at 12 knots.

Active Control for Stabilizers

Another possible way of improving seakeeping performance at higher speeds is to use active stabilizers. Since the performance that needed improvement was between following and beam seas where encounter periods are low and the AGOR2 had a relatively low GM_L, it was likely that activating the stabilizers could improve performance. Previous investigations had shown that active stabilizers were not effective at less than 15 knots. However, these investigations were for hull forms which displaced about 3000 tons.

At 9 knots, the AGOR 23 OR was met with inactive fins. However, it was interesting to investigate whether activation would result in improved seaworthiness. As can be seen in Figure 16, the effect of activating the stabilizers varied with wave heading. Figure 17 shows that at 12 knots, activating the fins resulted in an increase in the LSWHs and resulted in acceptable performance through Sea State 4 as required. Performance with only the aft fin active were identical to those with forward and aft fins active.

Seakeeping Assessment

A detailed seakeeping assessment was carried out for the AGOR2 with the stabilizers inactive at all speeds except 12 knots. Figure 18 presents the LSWHs for the "on station" criteria and Figure 19 presents the LSWHs for the "transit" criteria for 6, 9, and 12 knots. The ORs are met. Figures 20 and 21 give the LSWHs and PTOs for the "on station", "operating", and "transiting" criteria.

Station Keeping and Maneuvering Assessment

Since the SWATH variant of the AGOR2 is similar to the TAGOS-19 Contract Design, unpublished results from TAGOS-19 model experments and estimates were used to predict the performance of the AGOR2 design. Data from the wave drift force and current force experiments were used along with estimates of the wind forces to calculate the total external mean forces acting on the vessel under the stated environmental conditions. These forces were calculated over a series of wave headings from 180 degrees (head seas) to 0 degrees (following seas). The wind and wave forces were assumed to come from the same directions, but for each wave heading, the effect of the current was addressed at all headings from coincident to 180 degrees off wave heading. For each set of calculated wave heading-current angle combinations, the best heading for minimum external forces was established. The largest force values for the best heading results (i.e. best heading with the worst wave-current angle combination) were then used to size the thruster devices for the design.

The thruster locations were picked to be in the canard and stabilizer actuator spaces in the lower hull and are assumed to develop approximately 15 pounds force per horsepower (5.97 newtons per kilowatt). Given the above assumptions, 300 HP of thrust would be required at the bow of the ship to hold position. Therefore, installing one 150 HP thruster in each corner of the vessel in each actuator room would provide the necessary thrust to hold the position.

The predicted tactical diameter for the AGOR2 design with design appendages is 435 meters (480 yards) or 8.2 ship lengths. This prediction is for calm water and is based upon the results of free-running radio control experiments for the TAGOS-19 Contract Design.

CONCLUSIONS

This investigation has shown that two different hull forms meet the seakeeping Operational Requirements for the AGOR 23. The modified AGORRED2 has a relatively large GM_L. With active control of the stabilizers, the hull form denoted AGOR2 has acceptable seakeeping performance. Although both of these configurations meet the OR, the seakeeping performance of the AGORRED2 is better. This can be traced to differences in GM_L, waterplane area, and lower hull length. The station keeping requirements are met by the AGOR2 with properly sized thrusters. The ability of the AGORRED2 to meet the station keeping requirements was not evaluated.

ACKNOWLEDGEMENT

The authors wish to thank Dr. Ernest E. Zarnick of DTNSRDC who designed the automatic control system for the AGOR2.

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4. McCreight, Kathryn K., and Stahl, Ralph, "Recent Advances in the Seakeeping Assessment of Ships", Naval Engineers Journal (May 1985).

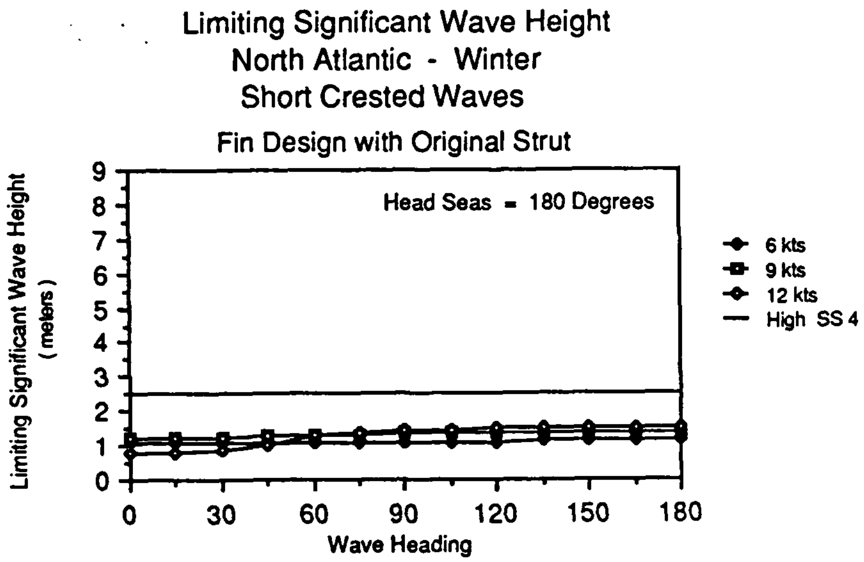

Figure 1 - Limiting Significant Wave Height for Transit Criteria as a Function of Relative Wave Heading for original AGORRED2 Design

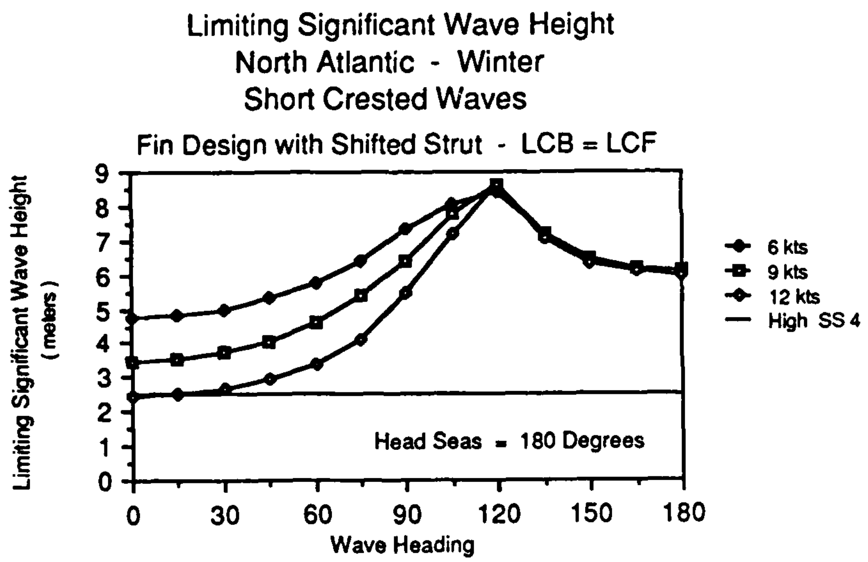

Figure 2 - Limiting Significant Wave Height for Transit Criteria as a Function of Relative Wave Heading for AGORRED2 Design with LCB and LCF Coincident

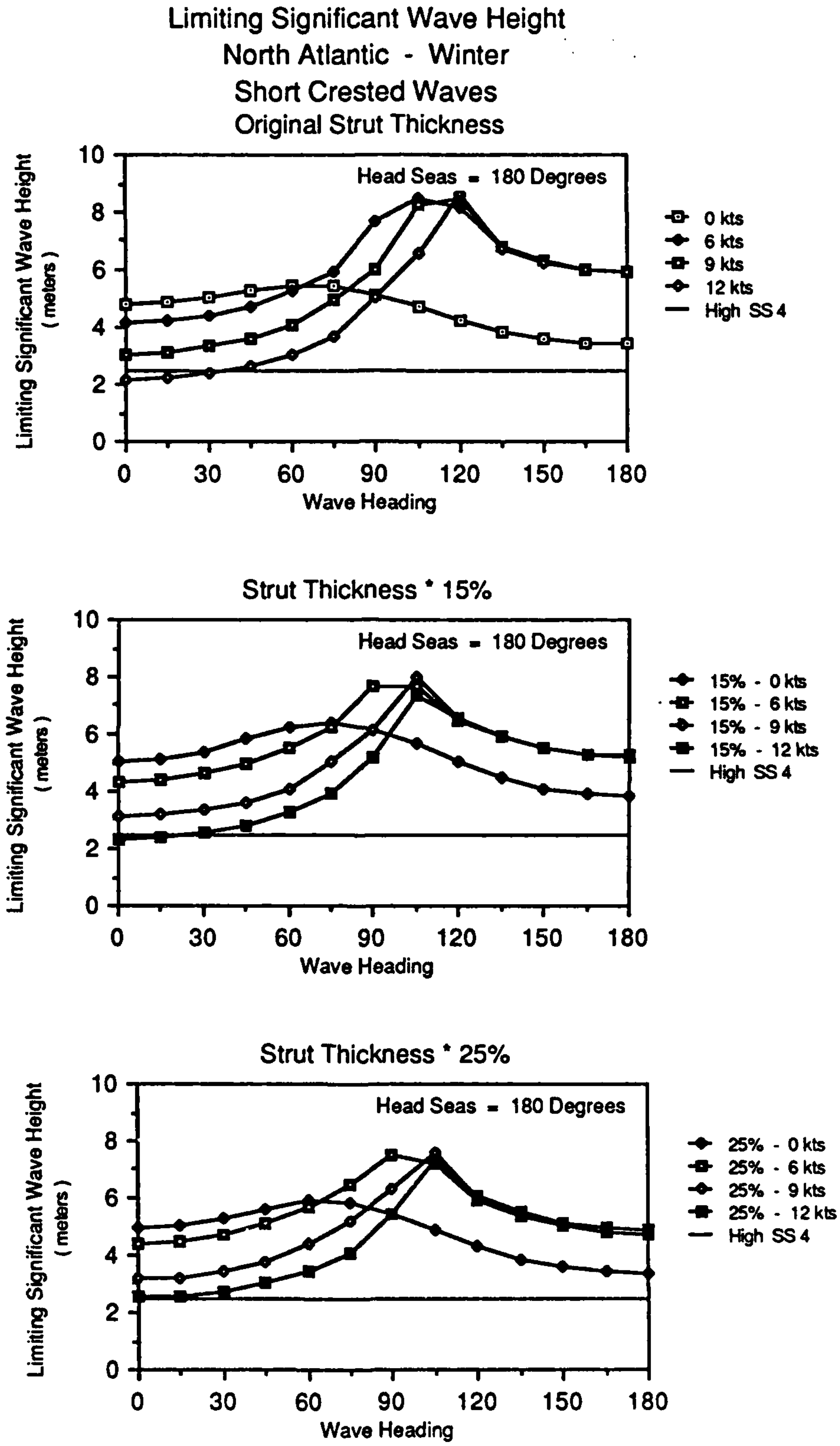

Figure 3 - Limiting Significant Wave Height for Transit Criteria as a Function of Relative Wave Heading for AGORRED2 Design with Various Strut Thicknesses

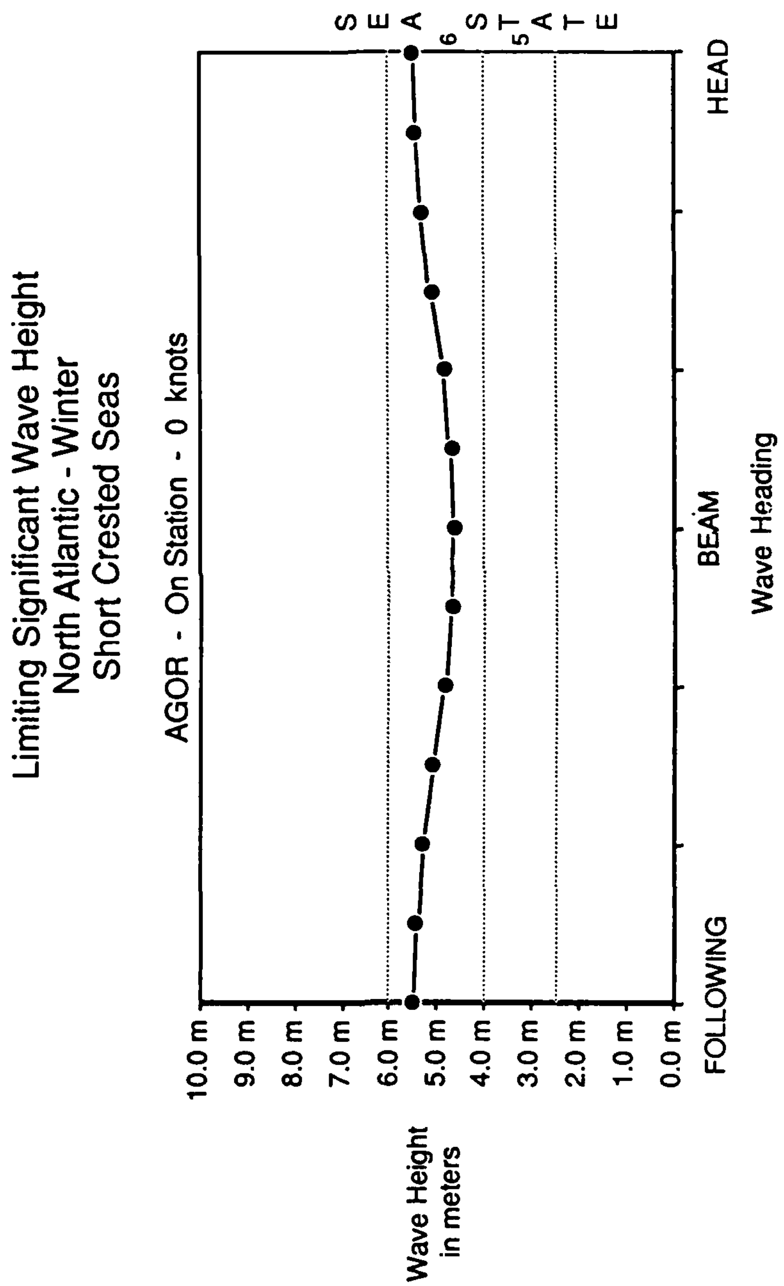

Figure 4 - Limiting Significant Wave Height for On Station Criteria as a Function of Relative Wave Heading for AGOR Design

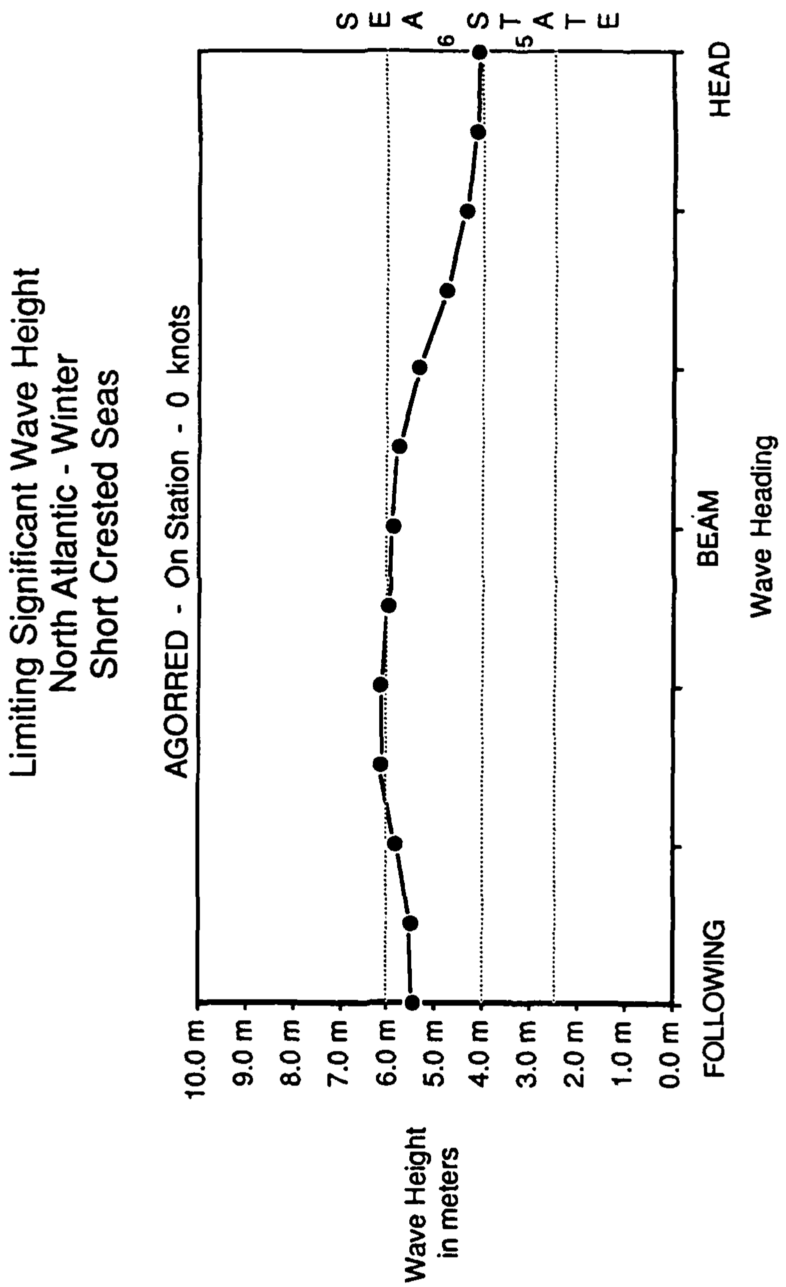

Figure 5 - Limiting Significant Wave Height for On Station Criteria as a Function of Relative Wave Heading for AGORRED Design

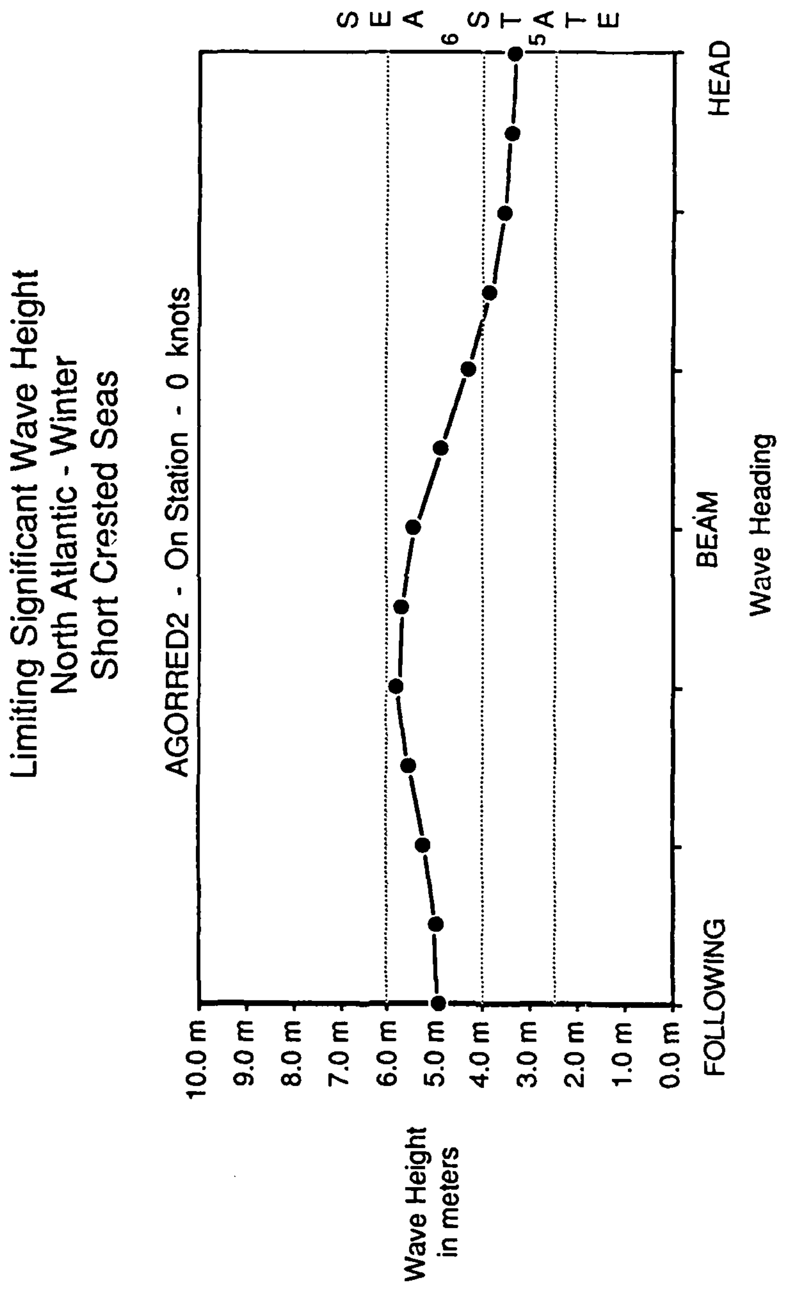

Figure 6 - Limiting Significant Wave Height for On Station Criteria as a Function of Relative Wave Heading for AGORRED2 Design

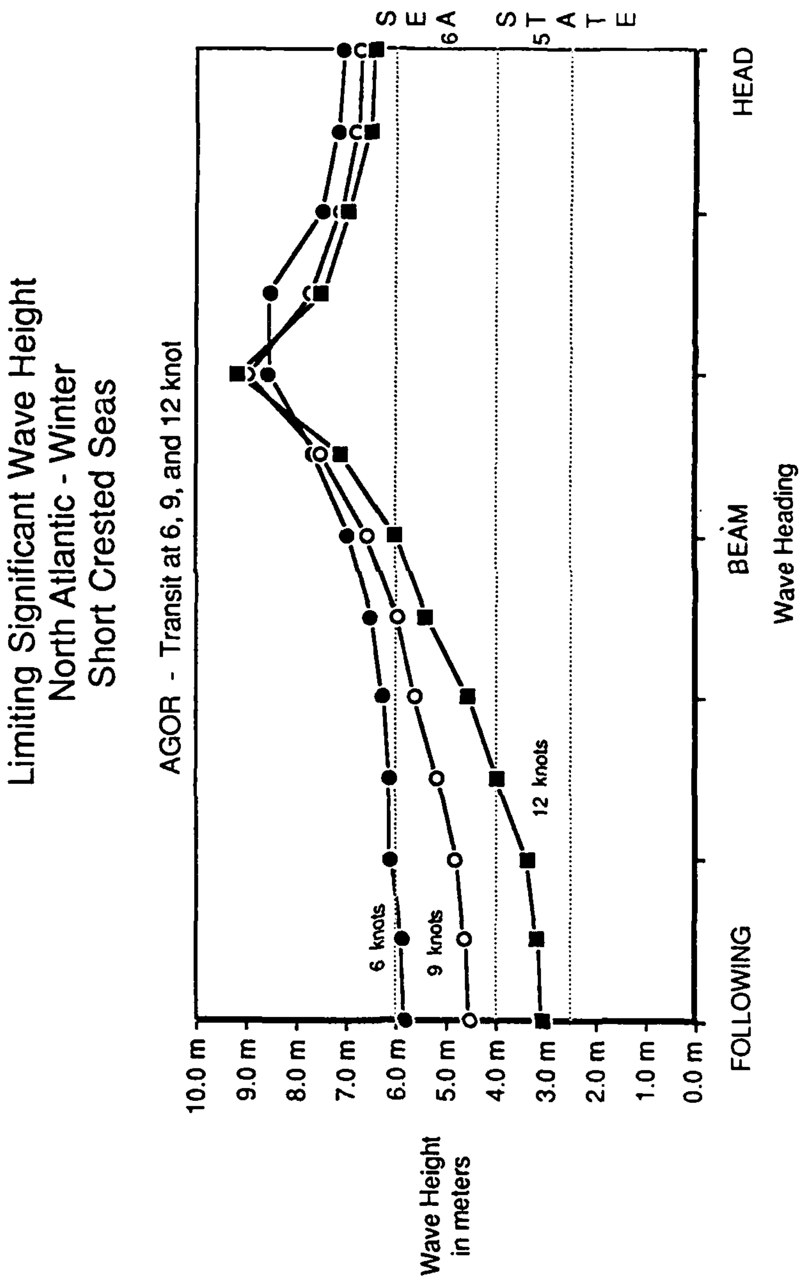

Figure 7 - Limiting Significant Wave Height for Transit Criteria as a Function of Relative Wave Heading for AGOR Design

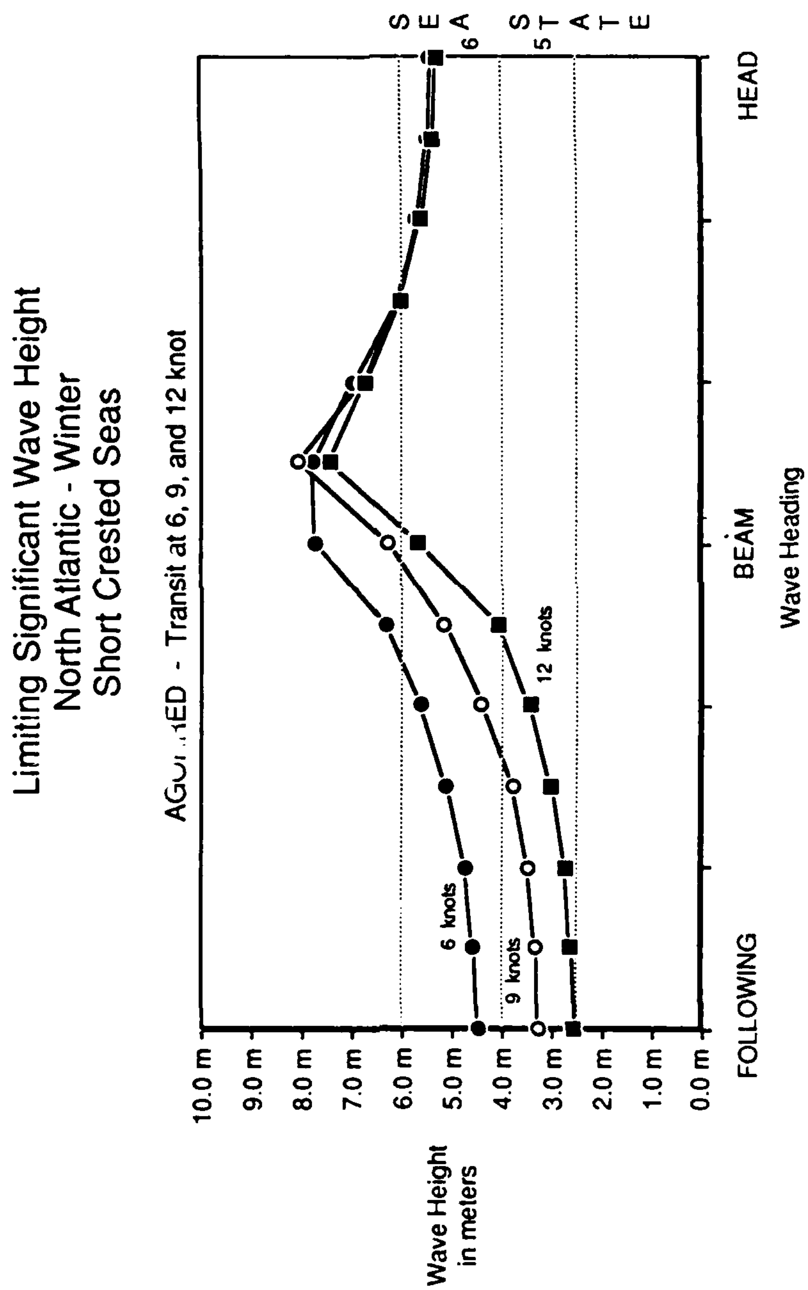

Figure 8 - Limiting Significant Wave Height for Transit Criteria as a Function of Relative Wave Heading for AGORRED Design

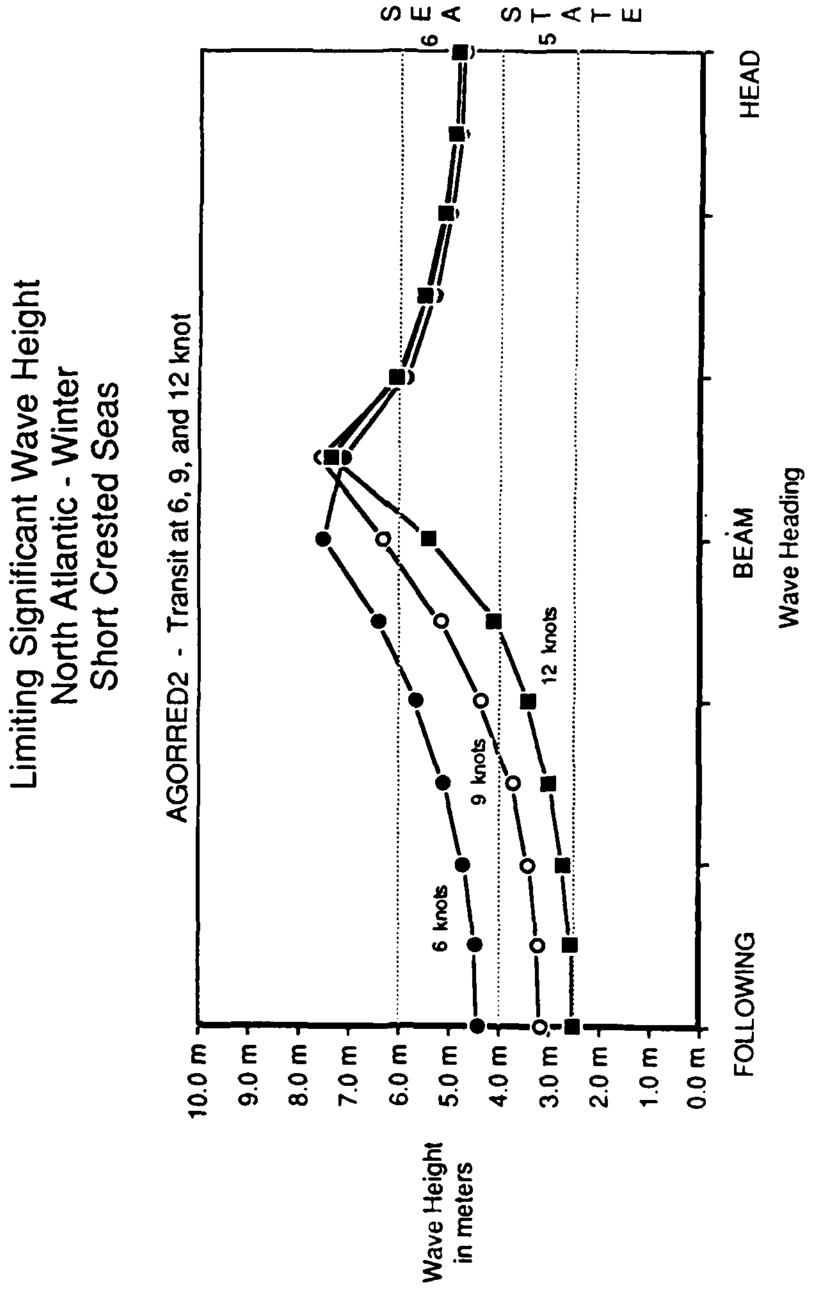

Figure 9 - Limiting Significant Wave Height for Transit Criteria as a Function of Relative Wave Heading for AGORRED2 Design

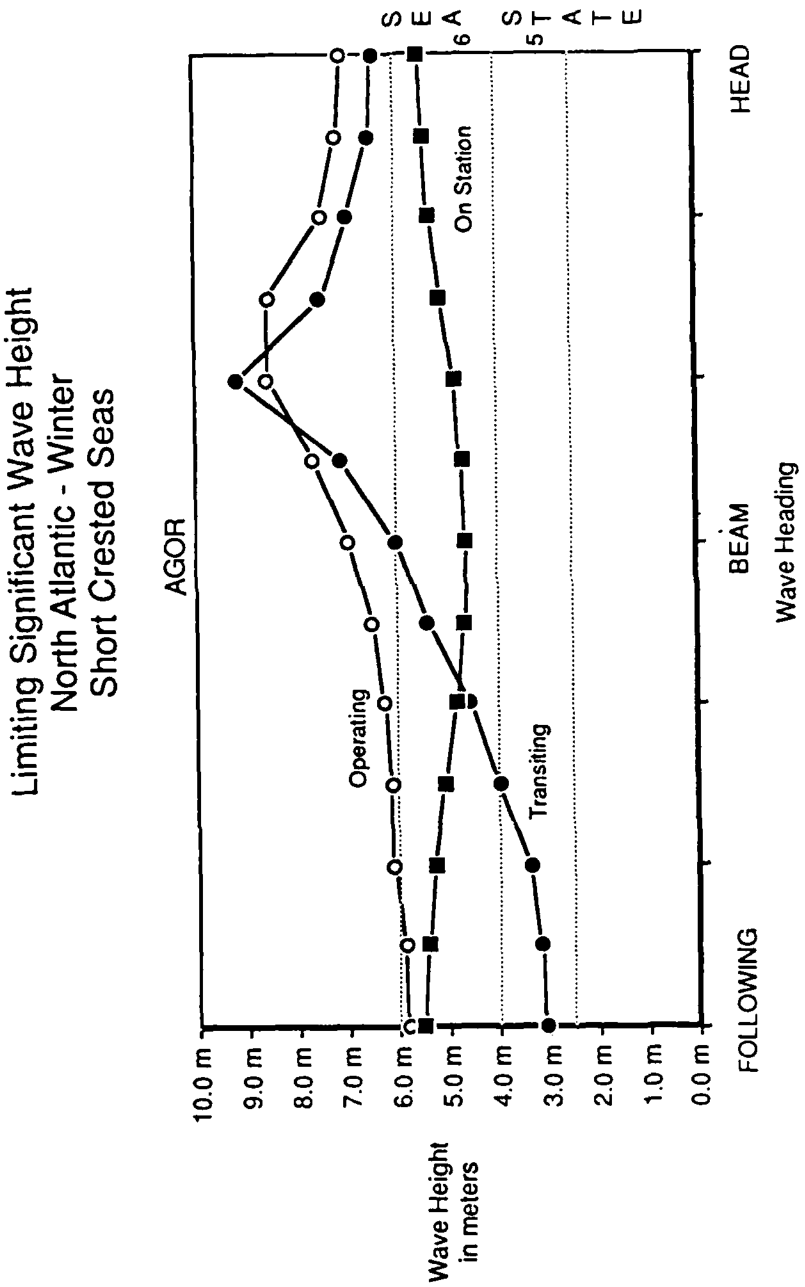

Figure 10 - Limiting Significant Wave Height as a Function of Relative Wave Heading for Various Criteria for AGOR Design

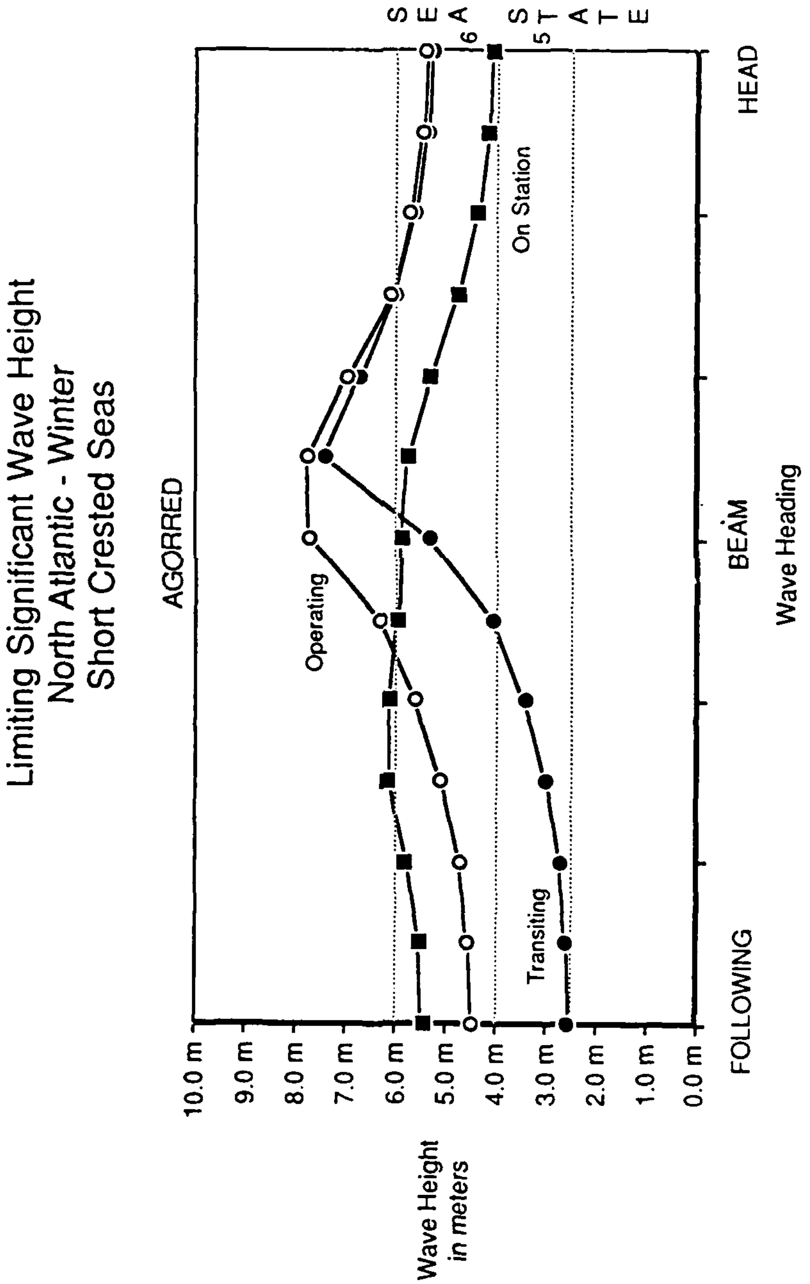

Figure 11 - Limiting Significant Wave Height as a Function of Relative Wave Heading for Various Criteria for AGORRED Design

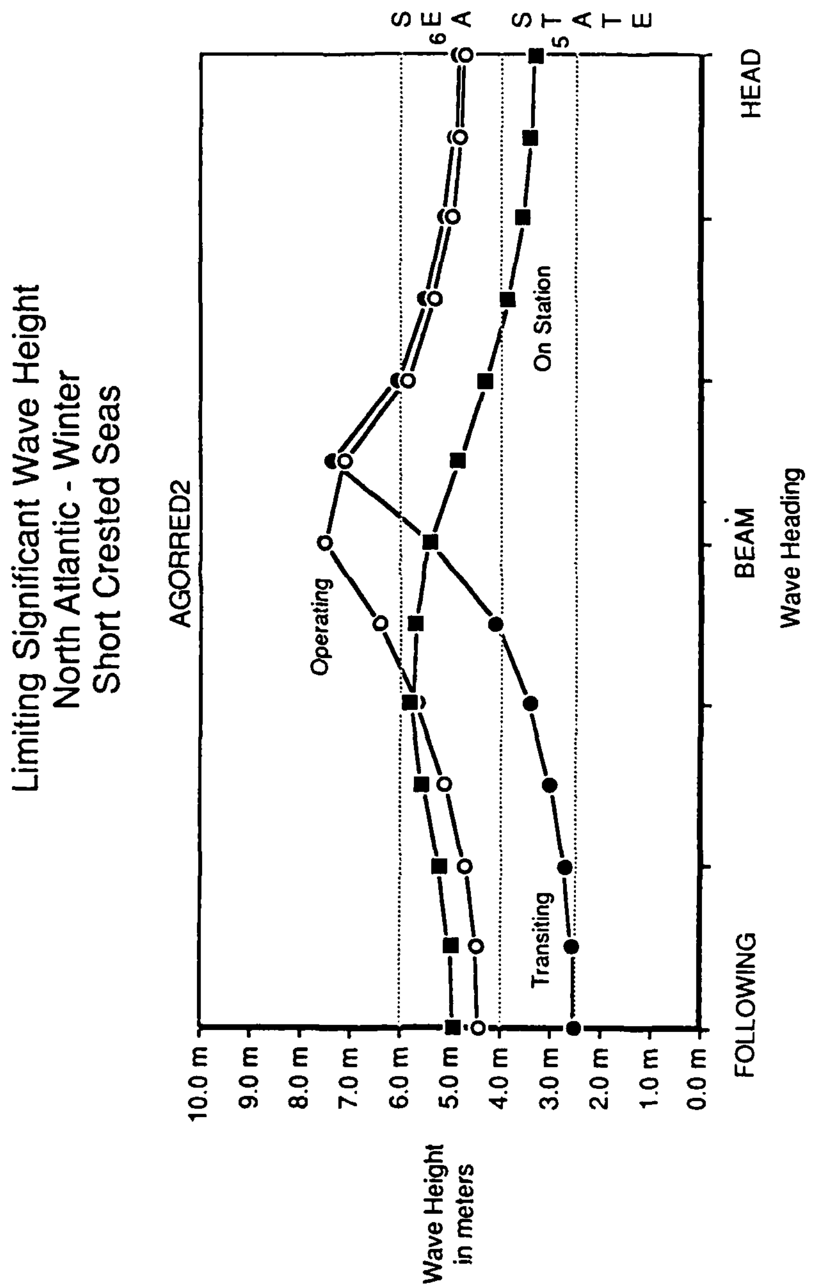

Figure 12 - Limiting Significant Wave Height as a Function of Relative Wave Heading for Various Criteria for AGORRED2 Design

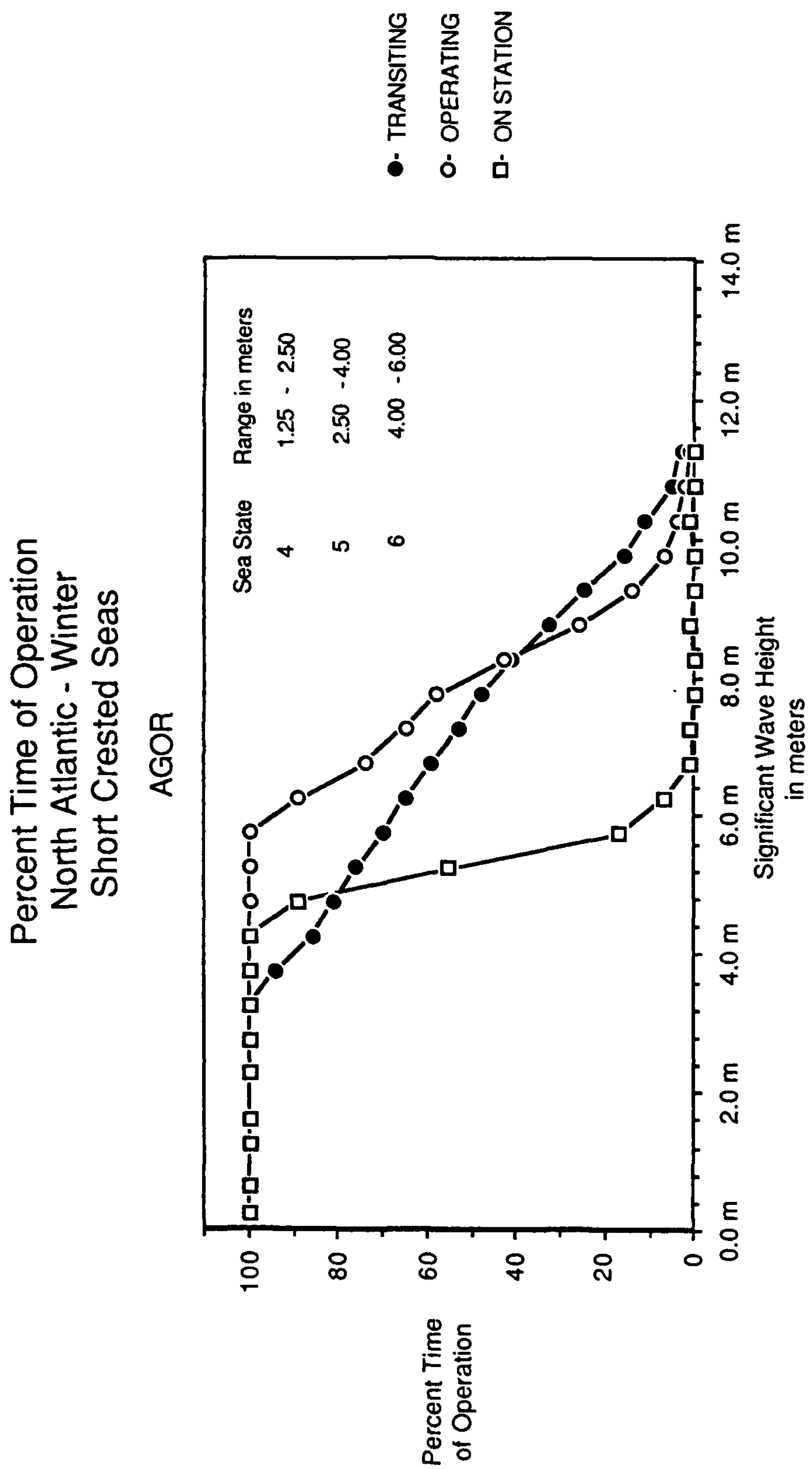

Figure 13 - Percent Time of Operation as a Function of Significant Wave Height for AGOR Design

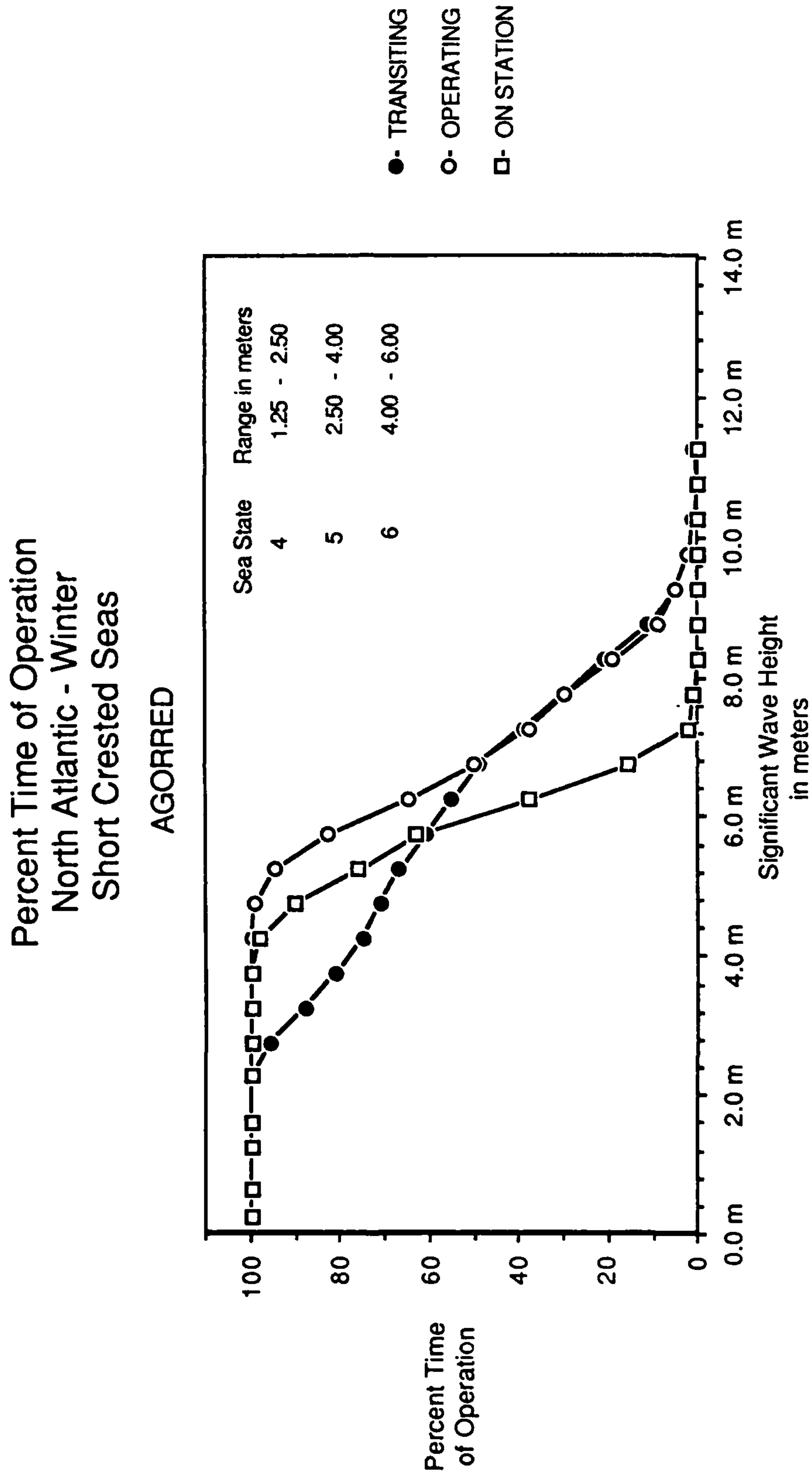

Figure 14 - Percent Time of Operation as a Function of Significant Wave Height for AGORRED Design

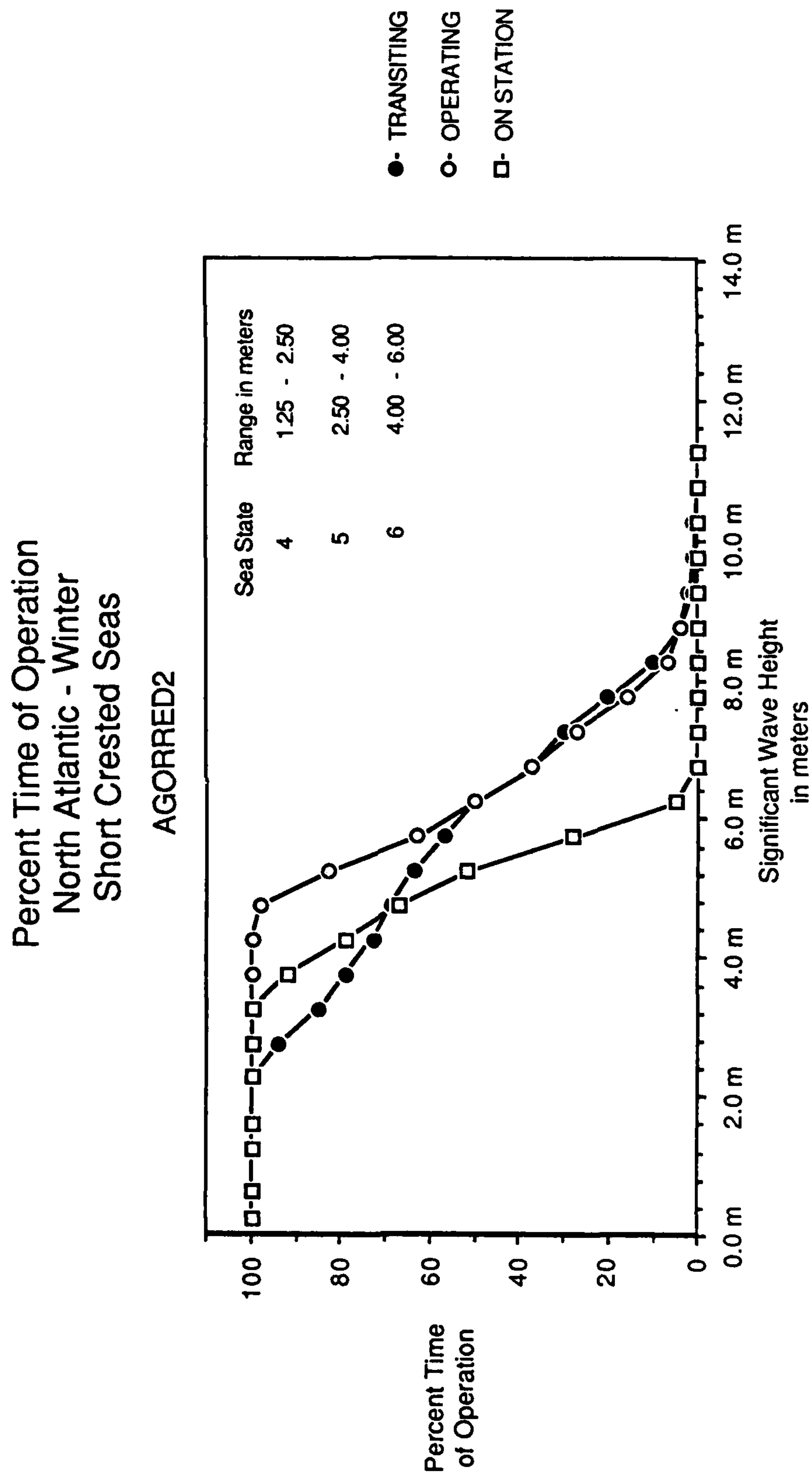

Figure 15 - Percent Time of Operation as a Function of Significant Wave Height for AGORRED2 Design

Limiting Significant Wave Height
North Atlantic - Winter
Short Crested Seas

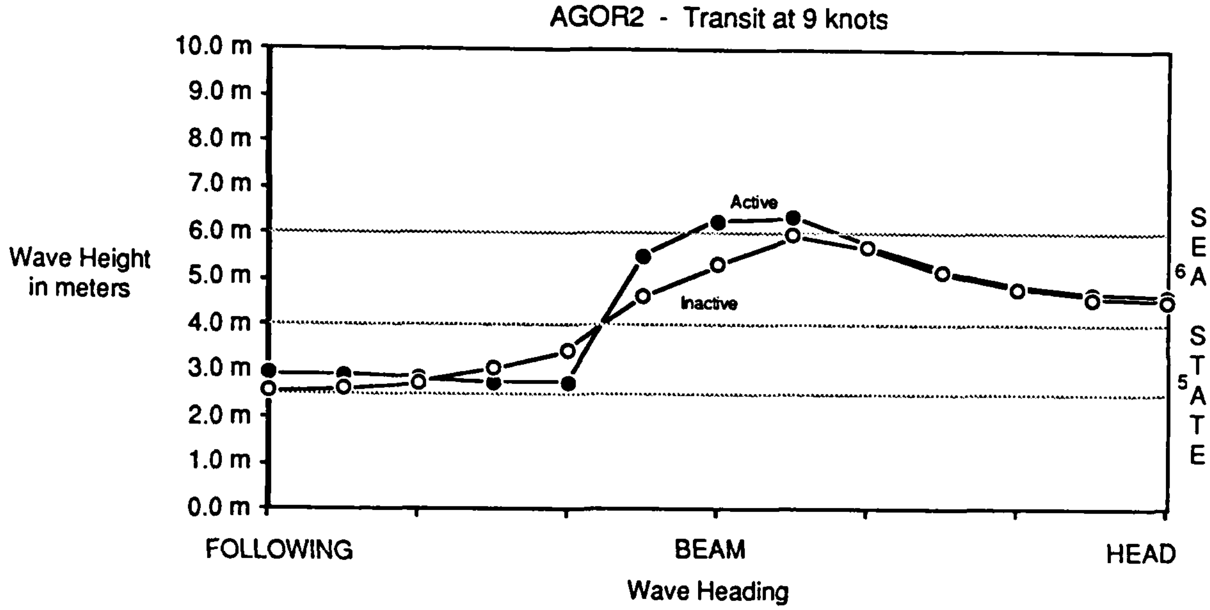

Figure 16 - Limiting Significant Wave Height as a Function of Relative Wave Heading for AGOR2 at 9 knots with Fixed and Active Stabilizers

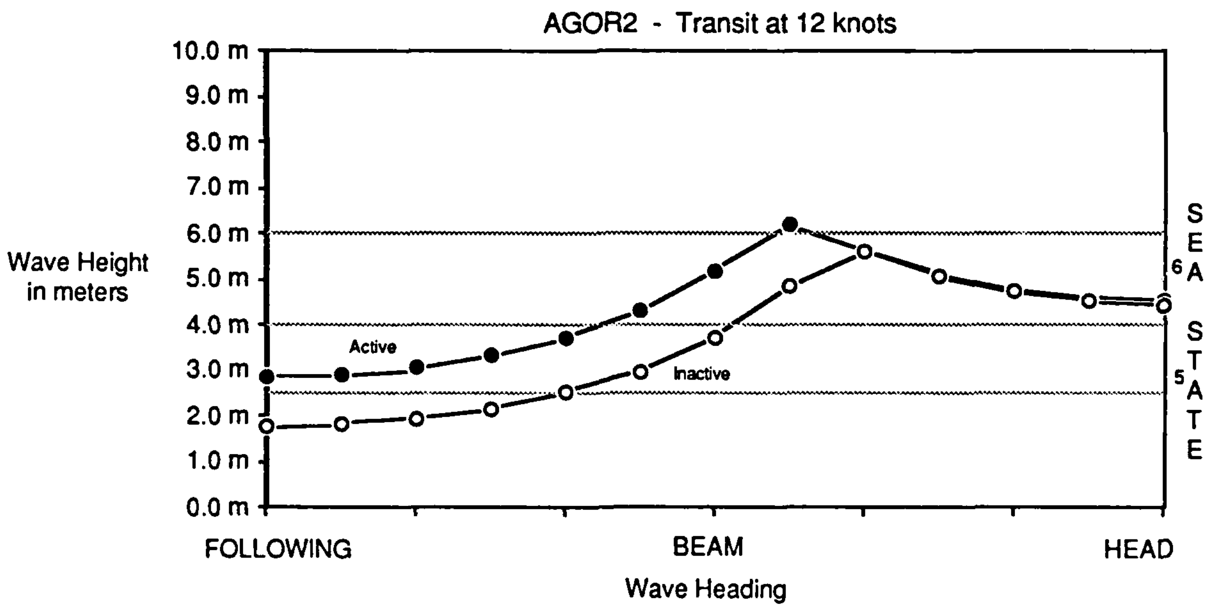

Figure 17 - Limiting Significant Wave Height as a Function of Relative Wave Heading for AGOR2 at 12 knots with Fixed and Active Stabilizers

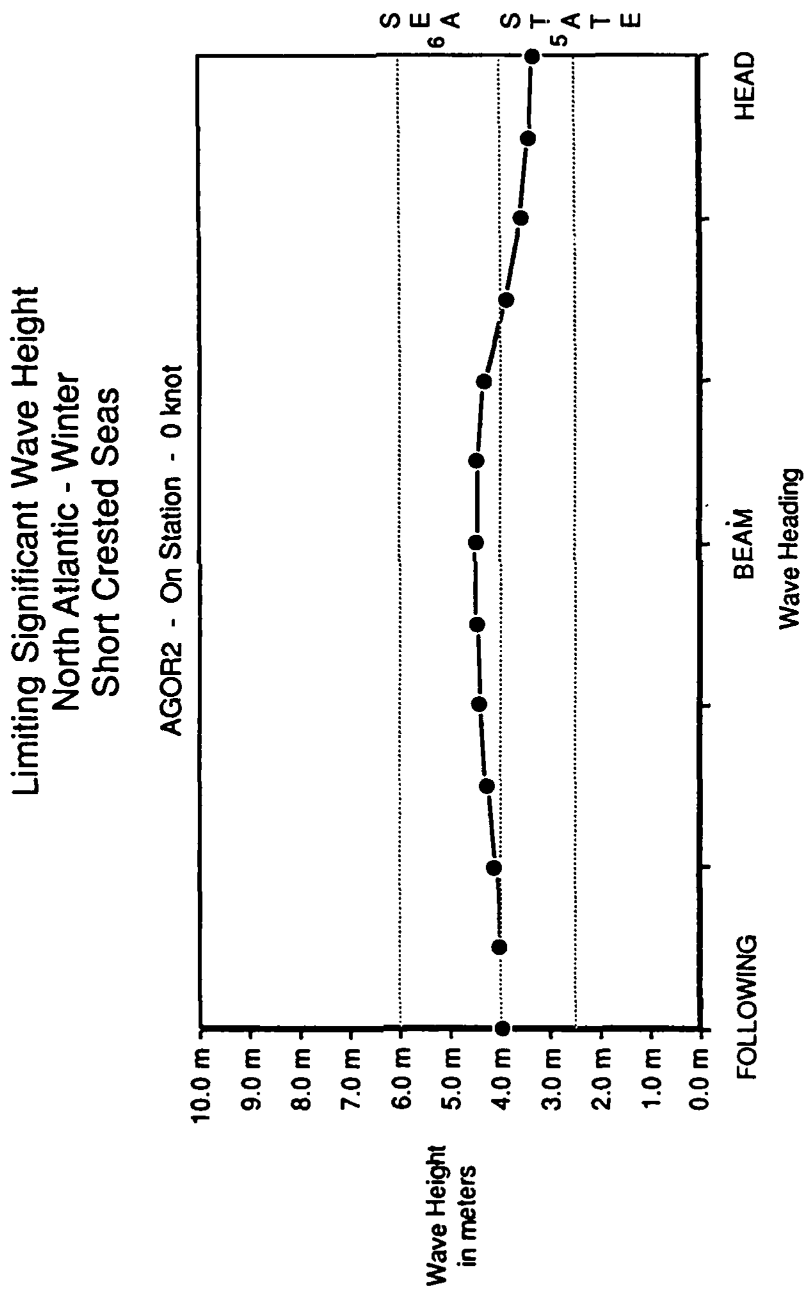

Figure 18 - Limiting Significant Wave Height for On Station Criteria as a Function of Relative Wave Heading for AGOR2 Design

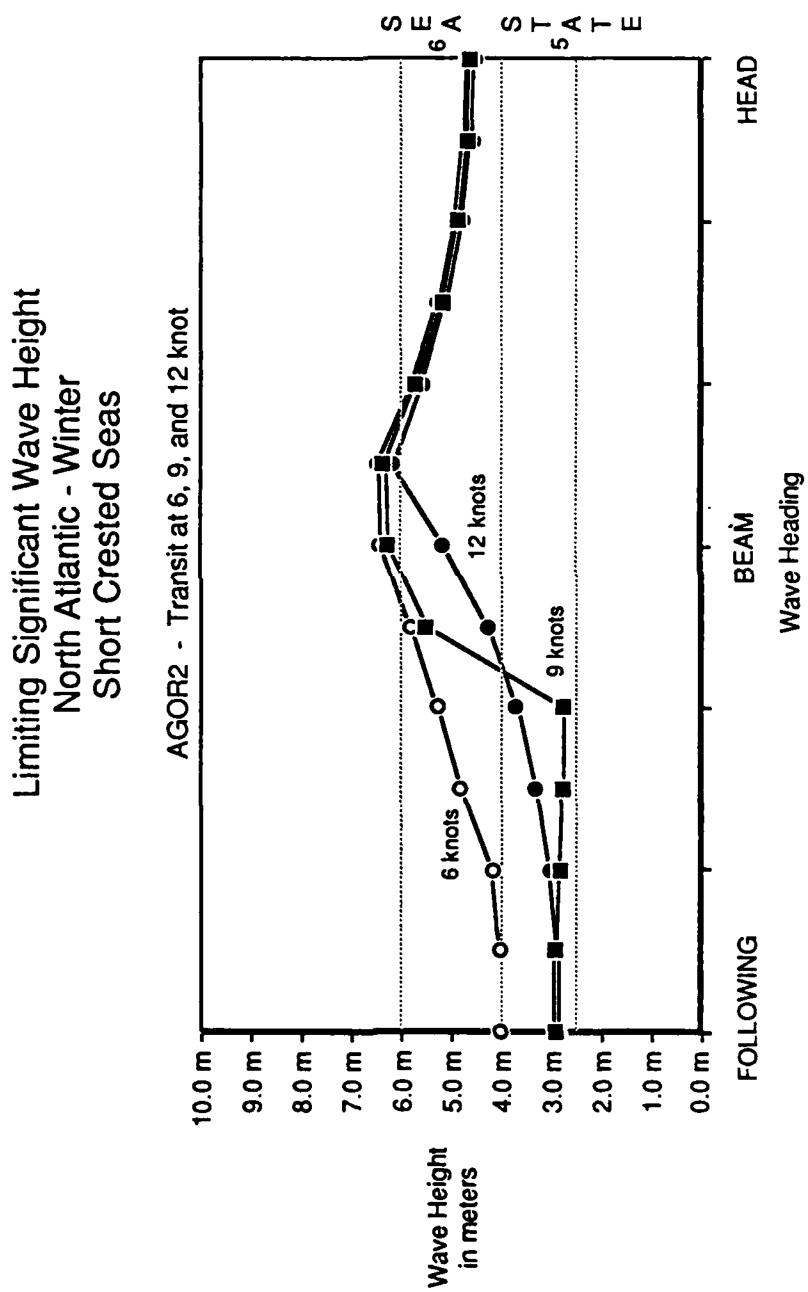

Figure 19 - Limiting Significant Wave Height for Transit Criteria as a Function of Relative Wave Heading for AGOR2 Design

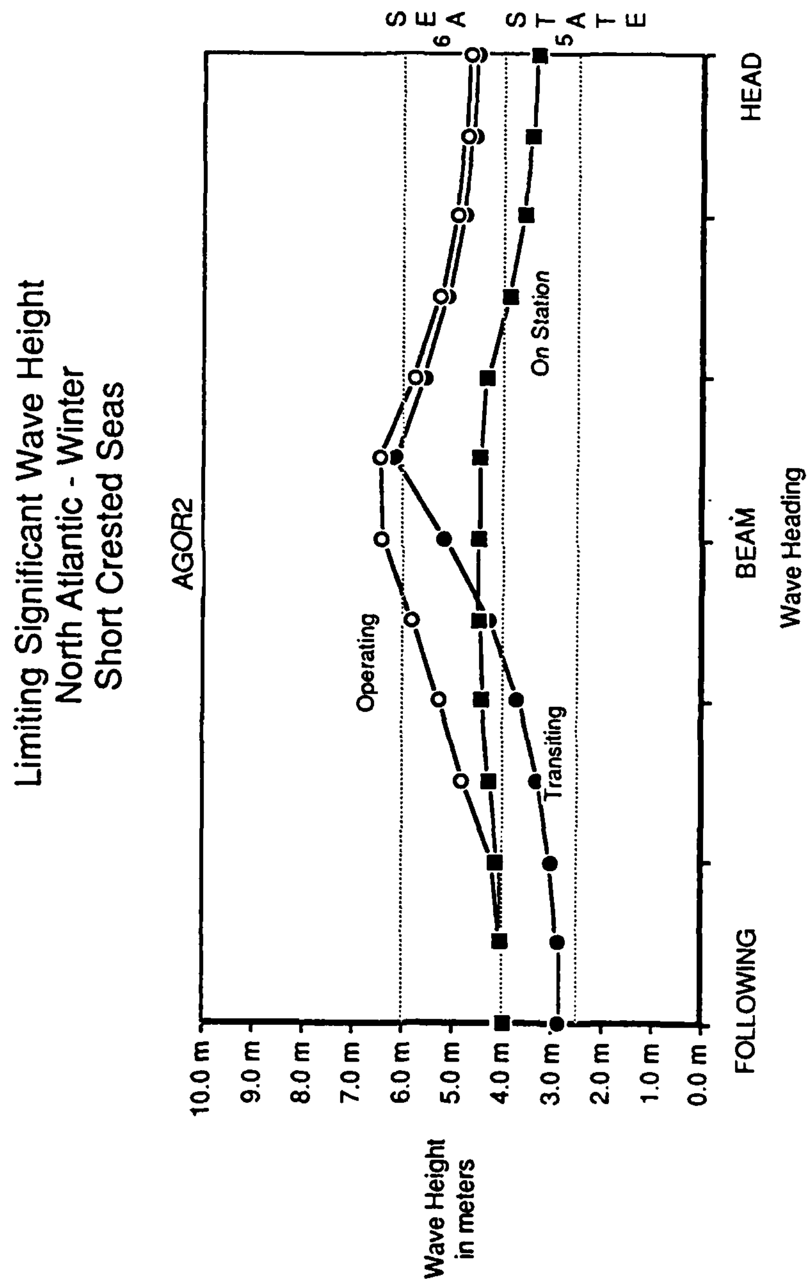

Figure 20 - Limiting Significant Wave Height as a Function of Relative Wave Heading for Various Criteria for AGOR2 Design

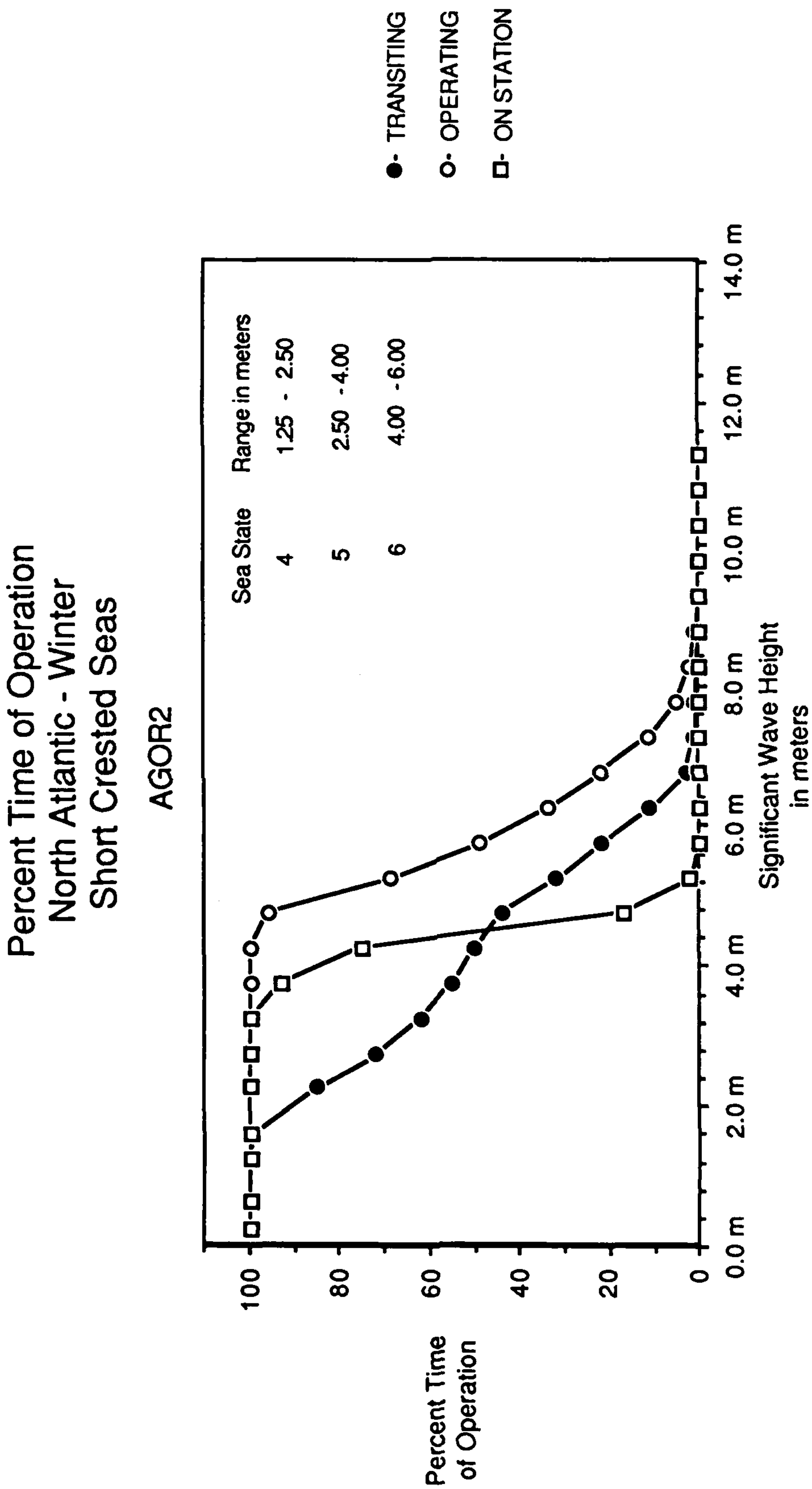

Figure 21 - Percent Time of Operation as a Function of Significant Wave Height for AGOR2 Design

	Transit	Operate	On Station
Roll*, deg.	8	8	5
Pitch*, deg.	3	3	3
Deck Wetnesses / hr.	30	30	5
Slams / hr.	20	20	5
Vertical Acceleration, g's	0.4	0.4	0.2
Acc. Measurement Loc.	Bridge	Transom	Boom Tip

* Significant Amplitude

Table 1 - AGOR-23 Proposed Mission Criteria

CONFIGURATION	DISPLACEMENT	DRAFT
AGOR	3738.9 tonne (3680.0 LTSW)	6.31 m (20.70 ft)
AGORRED	2266.7 tonne (2231.0 LTSW)	5.15 m (16.90 ft)
AGORRED2	1795.3 tonne (1767.0 LTSW)	4.91 m (16.10 ft)

Table 2 - Required Displacements and Drafts

ORIGINAL AGORRED2

TOTAL DPL	1720.0 tonne	(1693.0 LTSW)
LENGTH	70.02 m	(229.73 ft)
STRUT LENGTH	51.82 m	(170.02 ft)
BEAM	18.20 m	(59.70 ft)
DRAFT	4.91 m	(16.10 ft)
LCB (from nose)	32.43 m	(106.39 ft)
LCF (from nose)	31.35 m	(102.87 ft)
GML	11.70 m	(38.40 ft)
GMT	2.43 m	(7.96 ft)
SD	16.06 m	(52.70 ft)
KG	6.50 m	(21.34 ft)
KB	2.22 m	(7.27 ft)
Awp	169.51 sq m	(1824.55 sq ft)

Table 3 - Summary of Characteristics of Original AGORRED2 Configuration

	AGOR		AGORRED		AGORRED2	
TOTAL DPL	3734.3 tonne	(3675.5 LTSW)	2242.6 tonne	(2207.3 LTSW)	1767.0 tonne	(1739.2 LTSW)
LENGTH	87.68 m	(287.68 ft)	72.63 m	(238.28 ft)	70.02 m	(229.73 ft)
STRUT LENGTH	64.99 m	(213.23 ft)	53.75 m	(176.35 ft)	51.82 m	(170.02 ft)
BEAM	23.00 m	(75.47 ft)	19.50 m	(63.98 ft)	18.80 m	(61.70 ft)
DRAFT	6.31 m	(20.70 ft)	5.15 m	(16.90 ft)	4.91 m	(16.10 ft)
LCB (from nose)	40.89 m	(134.16 ft)	33.90 m	(111.21 ft)	32.67 m	(107.17 ft)
LCF (from nose)	40.92 m	(134.26 ft)	33.87 m	(111.12 ft)	32.69 m	(107.24 ft)
GML	15.10 m	(49.54 ft)	15.25 m	(50.03 ft)	15.29 m	(50.18 ft)
GMT	3.93 m	(12.90 ft)	3.85 m	(12.63 ft)	4.08 m	(13.37 ft)
SD	20.18 m	(66.20 ft)	16.55 m	(54.30 ft)	16.06 m	(52.70 ft)
KG	6.98 m	(22.90 ft)	6.43 m	(21.09 ft)	6.50 m	(21.34 ft)
KB	2.90 m	(9.51 ft)	2.46 m	(8.07 ft)	2.30 m	(7.54 ft)
Awp	282.48 sq m	(3040.54 sq ft)	244.96 sq m	(2636.77 sq ft)	217.23 sq m	(2338.27 sq ft)

Table 4 - Summary of Characteristics of Modified AGOR, AGORRED, AGORRED2 Configurations

HULL

VERTICAL DIAMETER	5.06 m	(16.61 ft)
TRANSVERSE DIAMETER	7.09 m	(23.25 ft)
LENGTH	87.68 m	(287.68 ft)
FORWARD OVERHANG	9.54 m	(31.29 ft)
AFT OVERHANG	13.16 m	(43.16 ft)
NOSE LENGTH	5.29 m	(17.36 ft)
CENTER LENGTH	70.20 m	(230.32 ft)
TAIL LENGTH	12.19 m	(40.00 ft)

STRUT

THICKNESS	2.83 m	(9.27 ft)
LENGTH	64.99 m	(213.23 ft)
LENGTH OF ELLIPSE	30.07 m	(98.66 ft)
LENGTH OF CENTER	9.44 m	(30.96 ft)
LENGTH OF PARABOLA	25.48 m	(83.61 ft)
LENGTH - HULL T0 BOX	4.60 m	(15.09 ft)
STRUT SETBACK	9.54 m	(31.29 ft)

HULL DESCRIPTION

CDIAV1	3.50 m	(11.49 ft)	CDIAT	4.90 m	(16.09 ft)
CDIAV2	3.50 m	(11.49 ft)	CDIAT	4.90 m	(16.09 ft)
CDIAV3	5.06 m	(16.61 ft)	CDIAT	7.09 m	(23.25 ft)
CDIAV4	5.06 m	(16.61 ft)	CDIAT	7.09 m	(23.25 ft)
CDIAV5	3.50 m	(11.49 ft)	CDIAT	4.90 m	(16.09 ft)
CDIAV6	3.50 m	(11.49 ft)	CDIAT	4.90 m	(16.09 ft)
HSECL1	5.29 m	(17.36 ft)			
HSECL2	5.76 m	(18.91 ft)			
HSECL3	19.10 m	(62.67 ft)			
HSECL4	13.55 m	(44.45 ft)			
HSECL5	24.23 m	(79.51 ft)			
HSECL6	7.55 m	(24.78 ft)			
HSECL7	12.19 m	(40.00 ft)			

Table 5 - SWATY Hull Form Description of Modified AGOR

HULL

VERTICAL DIAMETER	4.28 m	(14.04 ft)
TRANSVERSE DIAMETER	5.99 m	(19.66 ft)
LENGTH	72.63 m	(238.28 ft)
FORWARD OVERHANG	7.96 m	(26.12 ft)
AFT OVERHANG	10.91 m	(35.81 ft)
NOSE LENGTH	4.38 m	(14.38 ft)
CENTER LENGTH	58.15 m	(190.77 ft)
TAIL LENGTH	10.10 m	(33.13 ft)

STRUT

THICKNESS	2.95 m	(9.68 ft)
LENGTH	53.75 m	(176.35 ft)
LENGTH OF ELLIPSE	24.87 m	(81.60 ft)
LENGTH OF CENTER	7.80 m	(25.60 ft)
LENGTH OF PARABOLA	21.08 m	(69.15 ft)
LENGTH - HULL T0 BOX	4.22 m	(13.86 ft)
STRUT SETBACK	7.96 m	(26.12 ft)

HULL DESCRIPTION

CDIAV1	2.97 m	(9.73 ft)	CDIAT	4.15 m	(13.62 ft)
CDIAV2	2.97 m	(9.73 ft)	CDIAT	4.15 m	(13.62 ft)
CDIAV3	4.28 m	(14.04 ft)	CDIAT	5.99 m	(19.66 ft)
CDIAV4	4.28 m	(14.04 ft)	CDIAT	5.99 m	(19.66 ft)
CDIAV5	2.97 m	(9.73 ft)	CDIAT	4.15 m	(13.62 ft)
CDIAV6	2.97 m	(9.73 ft)	CDIAT	4.15 m	(13.62 ft)
HSECL1	4.38 m	(14.38 ft)			
HSECL2	4.77 m	(15.66 ft)			
HSECL3	15.82 m	(51.91 ft)			
HSECL4	11.22 m	(36.82 ft)			
HSECL5	20.07 m	(65.85 ft)			
HSECL6	6.26 m	(20.53 ft)			
HSECL7	10.10 m	(33.13 ft)			

Table 6 - SWATY Hull Form Description of Modified AGORRED

HULL

VERTICAL DIAMETER	3.76 m	(12.35 ft)
TRANSVERSE DIAMETER	5.27 m	(17.29 ft)
LENGTH	70.02 m	(229.73 ft)
FORWARD OVERHANG	7.58 m	(24.86 ft)
AFT OVERHANG	10.62 m	(34.85 ft)
NOSE LENGTH	4.22 m	(13.86 ft)
CENTER LENGTH	56.06 m	(183.93 ft)
TAIL LENGTH	9.74 m	(31.94 ft)

STRUT

THICKNESS	2.74 m	(9.00 ft)
LENGTH	51.82 m	(170.02 ft)
LENGTH OF ELLIPSE	23.98 m	(78.67 ft)
LENGTH OF CENTER	7.52 m	(24.68 ft)
LENGTH OF PARABOLA	20.32 m	(66.67 ft)
LENGTH - HULL T0 BOX	4.50 m	(14.75 ft)
STRUT SETBACK	7.58 m	(24.86 ft)

HULL DESCRIPTION

CDIAV1	2.61 m	(8.55 ft)	CDIAT	3.65 m	(11.97 ft)
CDIAV2	2.61 m	(8.55 ft)	CDIAT	3.65 m	(11.97 ft)
CDIAV3	3.76 m	(12.35 ft)	CDIAT	5.27 m	(17.29 ft)
CDIAV4	3.76 m	(12.35 ft)	CDIAT	5.27 m	(17.29 ft)
CDIAV5	2.61 m	(8.55 ft)	CDIAT	3.65 m	(11.97 ft)
CDIAV6	2.61 m	(8.55 ft)	CDIAT	3.65 m	(11.97 ft)
HSECL1	4.22 m	(13.86 ft)			
HSECL2	4.60 m	(15.10 ft)			
HSECL3	15.26 m	(50.05 ft)			
HSECL4	10.82 m	(35.50 ft)			
HSECL5	19.35 m	(63.49 ft)			
HSECL6	6.03 m	(19.79 ft)			
HSECL7	9.74 m	(31.94 ft)			

Table 7 - SWATY Hull Form Description of Modified AGORRED2

AGOR STABILIZERS	FWD FIN		AFT FIN	
CHORD	3.09 m	(10.15 ft)	4.38 m	(14.36 ft)
SPAN	4.02 m	(13.20 ft)	5.69 m	(18.66 ft)
MAX. THICKNESS	0.46 m	(1.52 ft)	0.66 m	(2.15 ft)
DIST. BETWEEN 1/4 CHORD AND NOSE	6.07 m	(19.90 ft)	68.13 m	(223.54 ft)
AREA	12.45 sq m	(133.99 sq ft)	24.90 sq m	(267.97 sq ft)
DISPLACEMENT	4.65 tonne	(4.58 LTSW)	13.17 tonne	(12.96 LTSW)
ASPECT RATIO	1.30		1.30	

AGORRED STABILIZERS	FWD FIN		AFT FIN	
CHORD	2.02 m	(6.63 ft)	4.04 m	(13.27 ft)
SPAN	2.63 m	(8.62 ft)	5.25 m	(17.24 ft)
MAX. THICKNESS	0.30 m	(0.99 ft)	0.61 m	(1.99 ft)
DIST. BETWEEN 1/4 CHORD AND NOSE	4.89 m	(16.04 ft)	59.50 m	(195.20 ft)
AREA	5.31 sq m	(57.19 sq ft)	21.25 sq m	(228.76 sq ft)
DISPLACEMENT	1.30 tonne	(1.28 LTSW)	10.38 tonne	(10.22 LTSW)
ASPECT RATIO	1.30		1.30	

AGORRED2 STABILIZERS	FWD FIN		AFT FIN	
CHORD	1.87 m	(6.13 ft)	3.73 m	(12.25 ft)
SPAN	2.43 m	(7.96 ft)	4.86 m	(15.93 ft)
MAX. THICKNESS	0.28 m	(0.92 ft)	0.56 m	(1.84 ft)
DIST. BETWEEN 1/4 CHORD AND NOSE	4.69 m	(15.39 ft)	57.49 m	(188.60 ft)
AREA	4.53 sq m	(48.79 sq ft)	18.13 sq m	(195.15 sq ft)
DISPLACEMENT	1.03 tonne	(1.01 LTSW)	8.18 tonne	(8.05 LTSW)
ASPECT RATIO	1.30		1.30	

Table 8 - Description of Stabilizers for AGOR, AGORRED, and AGORRED2 Configurations

AGOR2		
TOTAL DPL	1633.3 tonne	(1607.6 LTSW)
LENGTH	52.86 m	(173.42 ft)
STRUT LENGTH	44.41 m	(145.69 ft)
BEAM	18.29 m	(60.00 ft)
DRAFT	5.46 m	(17.90 ft)
LCB (from nose)	24.64 m	(80.85 ft)
LCF (from nose)	24.58 m	(80.63 ft)
GML	7.67 m	(25.16 ft)
GMT	2.22 m	(7.29 ft)
SD	15.85 m	(52.00 ft)
KG	6.98 m	(22.90 ft)
KB	2.52 m	(8.28 ft)
Awp	166.66 sq m	(1793.89 sq ft)

Table 9 - Summary of Characteristics of AGOR2 Configuration

AGOR2 STABILIZERS	FWD FIN		AFT FIN	
CHORD	2.35 m	(7.71 ft)	3.32 m	(10.90 ft)
SPAN	3.05 m	(10.02 ft)	4.32 m	(14.17 ft)
MAX. THICKNESS	0.35 m	(1.16 ft)	0.50 m	(1.63 ft)
DIST. BETWEEN 1/4 CHORD AND NOSE	3.78 m	(12.39 ft)	38.60 m	(126.63 ft)
AREA	7.18 sq m	(77.25 sq ft)	14.35 sq m	(154.45 sq ft)
DISPLACEMENT	4.08 tonne	(4.02 LTSW)	11.48 tonne	(11.30 LTSW)
ASPECT RATIO	1.30		1.30	

Table 10 - Description of Stabilizers for AGOR2 Configuration

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