Preliminary Draft Analysis of Alternative Routing Measures in the Vicinity of the Proposed State of Maine Floating Offshore Wind Research Array

USCG Navigation Center

Alexandria, Virginia

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Executive Summary

On October 1, 2021, BOEM received an application from the State of Maine Governor's Energy Office to lease 9,700 acres in federal waters in the Gulf of Maine to allow for the development of a small-scale array of floating offshore wind turbines (the Research Array). If developed, the proposed Research Array would consist of up to 12 floating offshore wind turbines capable of generating up to 144 megawatts (MW) of renewable energy. The State of Maine's proposed Research Array is located adjacent to the Eastern Approach Traffic Separation Scheme (TSS) and precautionary area which serves as the safe transit route for northern vessel traffic departing and arriving at the Port of Portland, Maine.

On March 31, 2022, the First Coast Guard District issued a notice of study in the Federal Register (FR) (87 FR 18800) announcing the intent to conduct the Approaches to Maine, New Hampshire, and Massachusetts Port Access Route Study (MNMPARS). The MNMPARS considered whether routing measure revisions were necessary to improve navigation safety due to factors such as planned or potential offshore development, current port capabilities and planned improvements, increased vessel traffic, changing vessel traffic patterns, weather, or navigational difficulty. The recommendations and results of this Port Access Route Study (PARS) are based on data gathered and analyzed, comments received to the docket, public outreach, and consultation with other government agencies. The notices, supporting documents and all comments received are available in the public docket (USCG-2022-0047).

The MNMPARS resulted in six safe access route recommendations, including the designation of a Portland Eastern Approach Fairway (Figure 1). This fairway was proposed to meet the needs of vessel traffic entering and exiting the Port of Portland via the Eastern Approach TSS, such as ensuring sufficient maneuvering space is provided for vessels to manage complex meeting situations and cross traffic as they depart or converge on the regulated traffic lanes. The fairway extends from the terminus of the Eastern Approach TSS, gradually expanding to 8 nautical miles before connecting with the proposed Gulf of Maine Fairway (Figure 1).

The recommended Portland Eastern Approach Fairway would reduce the proposed Research Array's available lease area to construct permanent or temporary floating offshore wind installations, facilities, and structures. To facilitate renewable energy development and maintain vessel traffic safety exiting and entering U.S. ports, the Office of Navigation Systems (CG-NAV) requested the United States Coast Guard Navigation Center (CG NAVCEN) examine potential fairway design alternatives to the MNMPARS recommended Portland Eastern Approach Fairway. CG NAVCEN modeled three alternative ship routing measure scenarios to determine the change in predicted collision, allision, and grounding frequencies caused by the addition of a proposed Research Array. Each alternative ship routing measure scenario was compared to the current waterway configuration and evaluated based on CG NAVCEN's incident frequency tolerability guidelines.

The findings presented in this preliminary draft report are for informational purposes to aid CG-NAV in evaluating potential navigation and vessel traffic risk profiles associated with various fairway design scenarios adjacent to a theoretical project comprising of a maximum of 12 floating offshore wind turbines.

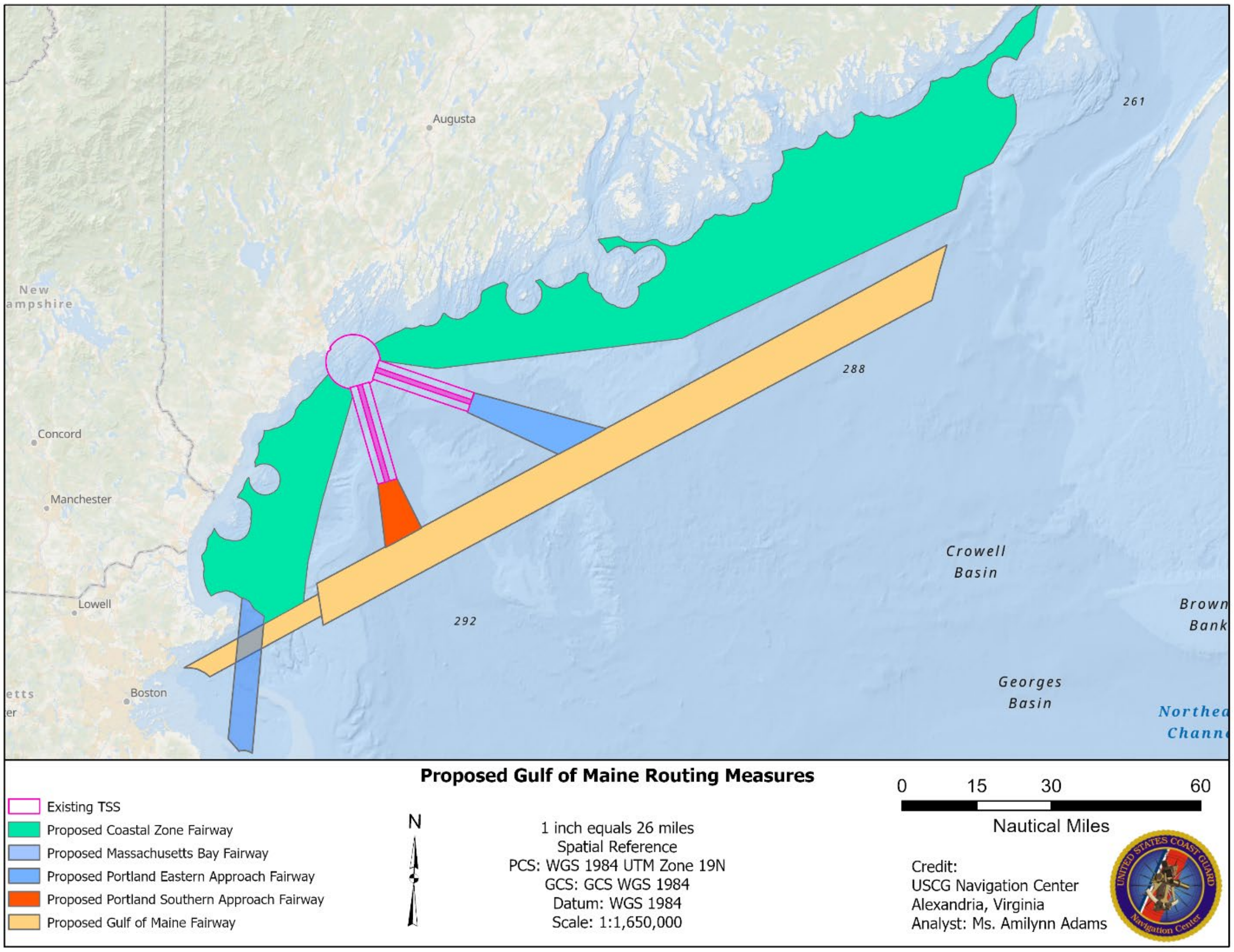

Figure 1-MNMPARS Recommended Fairways

The results of this preliminary draft analysis indicate that the introduction of wind turbines creates an intolerable increase in predicted allision frequency. A modification of the routing measures is necessary to reduce the change in predicted incident frequency to an acceptable level. The predicted incident frequencies between each of the alternative ship routing scenarios were deemed to be tolerable.[1] This finding enables the consideration of factors not directly related to navigation safety in determining the appropriate alternate routing measure.

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[1] CG NAVCEN Work Instruction 2022-01 Waterway Analysis Tactics, Techniques and Procedures, September 2022, available at: https://www.navcen.uscg.gov/sites/default/files/pdf/waterways/nsra/navcen_work_instruction_2022-01.pdf

Alternate Ship Routing Measure Scenarios

Three alternate ship routing measure scenarios were analyzed using the International Association of Marine Aids to Navigation and Lighthouse Authorities' (IALA) Waterways Risk Assessment Program (IWRAP), a modeling tool used to develop and evaluate predicted changes in vessel collision, allision, and grounding frequency. These alternate ship routing measure scenarios were designated *Charlie1, Charlie2,* and *Charlie3.*

Alternate Ship Routing Scenario 1, "Charlie1"

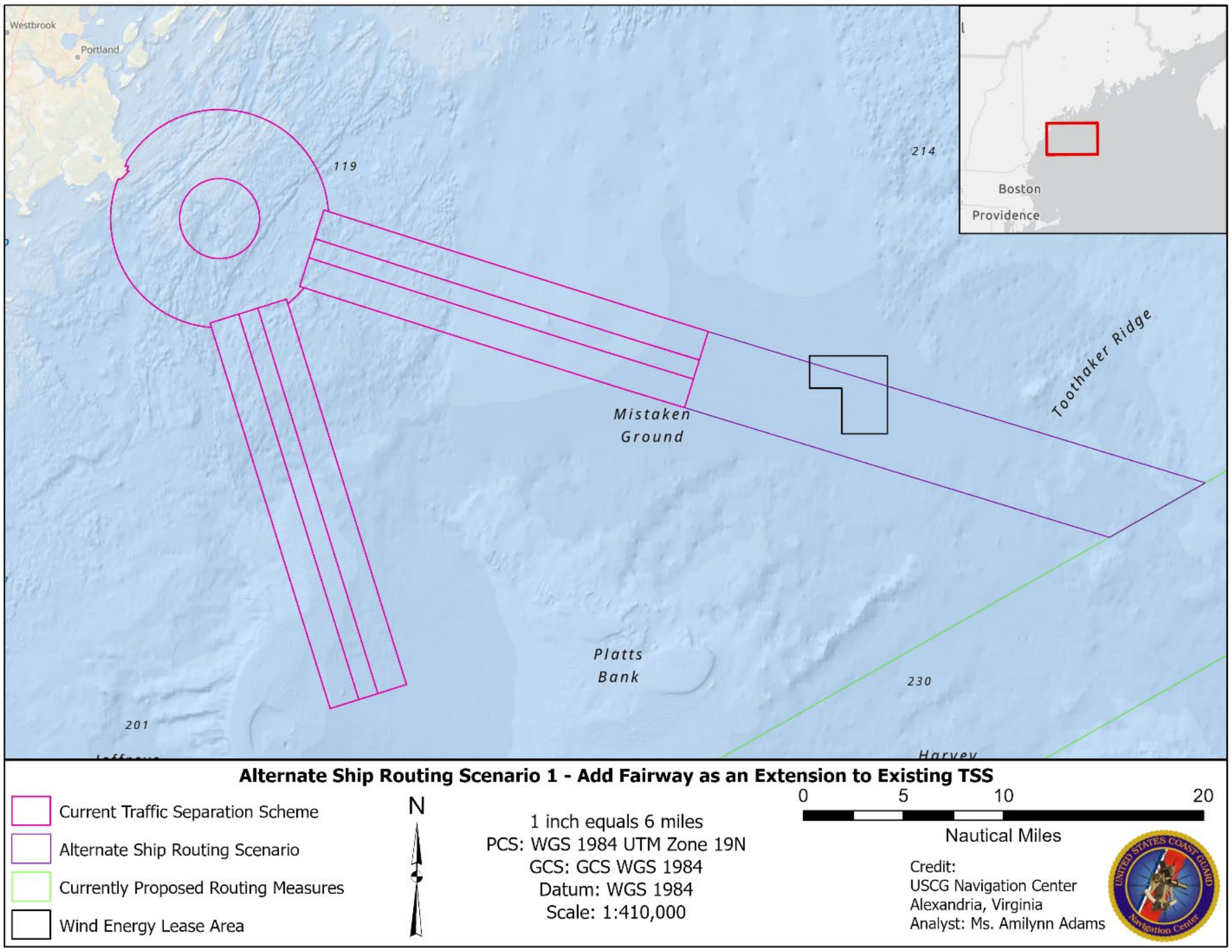


Figure 2-Alternate Ship Routing Scenario 1

Summary of routing measure adjustments:

- Current TSS unchanged.
- Fairway added and extended on same base course to existing TSS.
- Fairway intersects the Research Array wind energy area boundary.

Alternate Ship Routing Scenario 2 – "Charlie2"

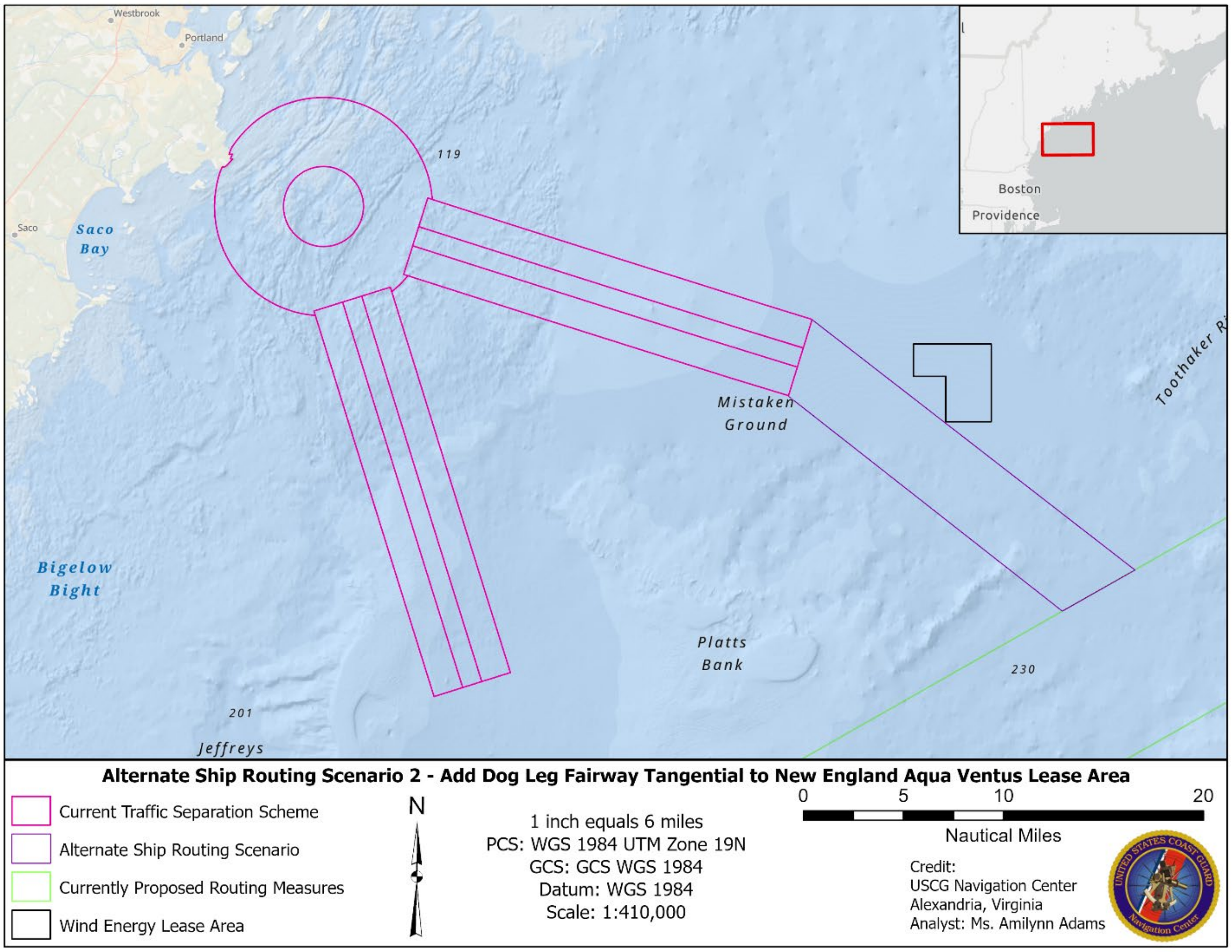


Figure 3-Alternate Ship Routing Scenario 2

Summary of routing measure adjustments:

- Current TSS unchanged.
- Fairway added and aligned on a course of 128°/308° T to from the terminus of the TSS, introducing an approximately 9° course change to the routing measures.
- Fairway is approximately tangential to the Research Array wind energy area boundary.

Alternate Ship Routing Scenario 3 – “Charlie3”

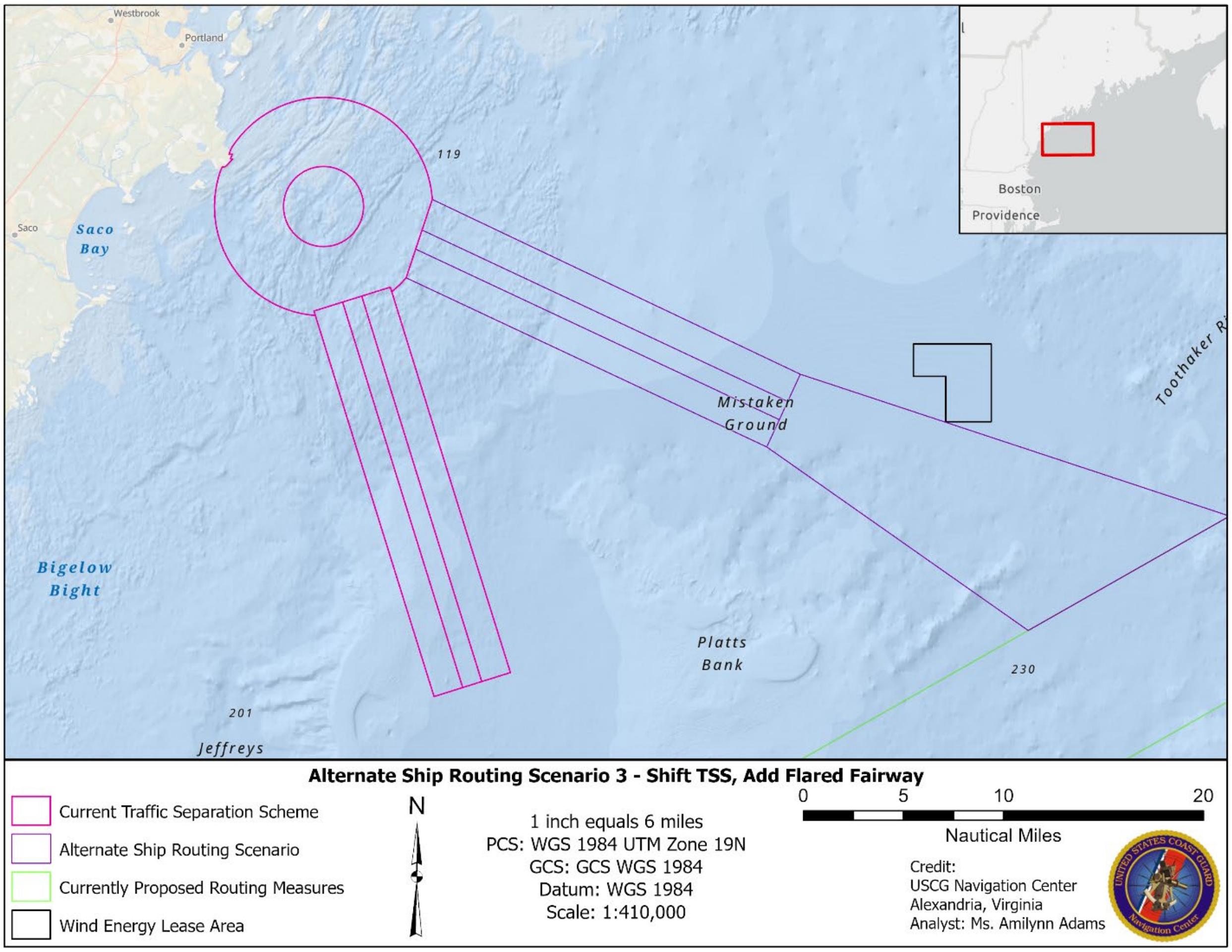


Figure 4-Alternate Ship Routing Scenario 3

Summary of routing measure adjustments:

- TSS shifted +8 degrees (clockwise) from 109°/289° T to 117°/297° T.
- Flared fairway added to the end of the shifted TSS.
- Flared fairway connects terminus of shifted TSS to proposed Gulf of Maine Fairway.

Overview of Model Adjustments

The Alpha model is the foundation for subsequent model modifications. The Bravo model is derived from the Alpha model by adding an installation, facility, or structure to the waterway. The Charlie model is derived from adjustments to traffic legs (routes) contained in the Alpha model. A familiarity with the legs contained in the Alpha model and the project design envelope for the installation, facility, or structures in the Bravo model is fundamental to understanding the results of the Charlie models.

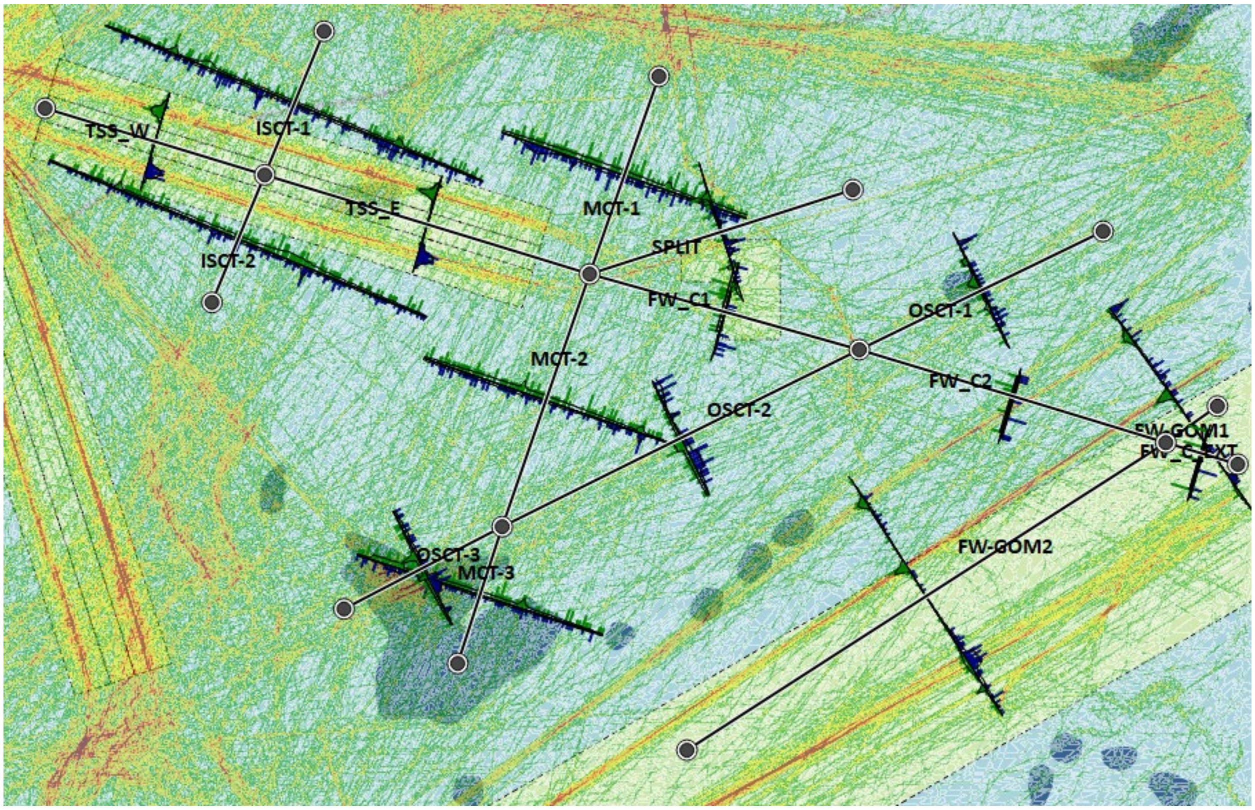


Figure 5-Alpha (base case) Model, source: IWRAP screen grab.

Alpha Model Legs

Leg Name	**Description**
TSS-W	Western end of Traffic Separation Scheme
TSS-E	Eastern end of Traffic Separation Scheme
ISCT-1	Inshore Crossing Traffic Leg 1
ISCT-2	Inshore Crossing Traffic Leg 2
MCT-1	Middle Crossing Traffic Leg 1
MCT-2	Middle Crossing Traffic Leg 2
MCT-3	Middle Crossing Traffic Leg 3
SPLIT	Abrupt course change at the end of the TSS, used predominantly by large cruise ships
FW_C1	Fairway Connector 1
FW_C2	Fairway Connector 2
FW_C_EXT	Fairway Connector Extension (added for model algorithm reasons)

OSCT-1	Offshore Crossing Traffic 1
OSCT-2	Offshore Crossing Traffic 2
OSCT-3	Offshore Crossing Traffic 3
FW-GOM1	Fairway – Gulf of Maine 1
FW-GOM2	Fairway – Gulf of Maine 2

Alpha Model Adjustments

No installations, facilities, or structures were introduced, and no traffic adjustments are made to the Alpha (base case) model.

Bravo Model Adjustments

Traffic

No traffic adjustments are made.

Installations, Facilities, or Structures

The proposed Research Array was added to the Bravo model in two hypothetical configurations, resulting in two Bravo models, Bravo1 and Bravo2. The Bravo1 model uses the condensed wind turbine generator footprint depicted in Figure 6. The Bravo2 model uses a more dispersed wind turbine generator footprint depicted in Figure 7.

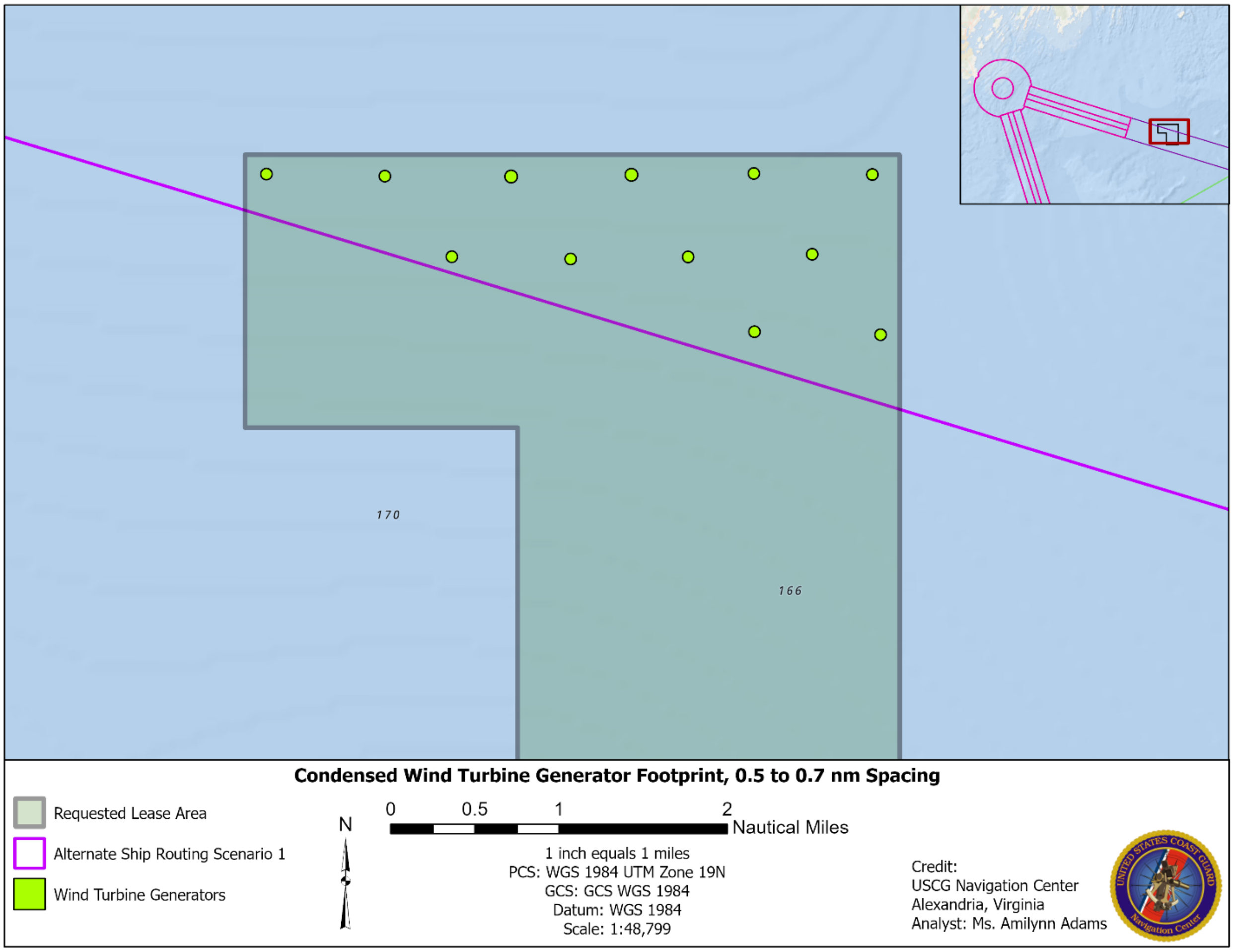


Figure 6-Notional Condensed Wind Turbine Generator Footprint

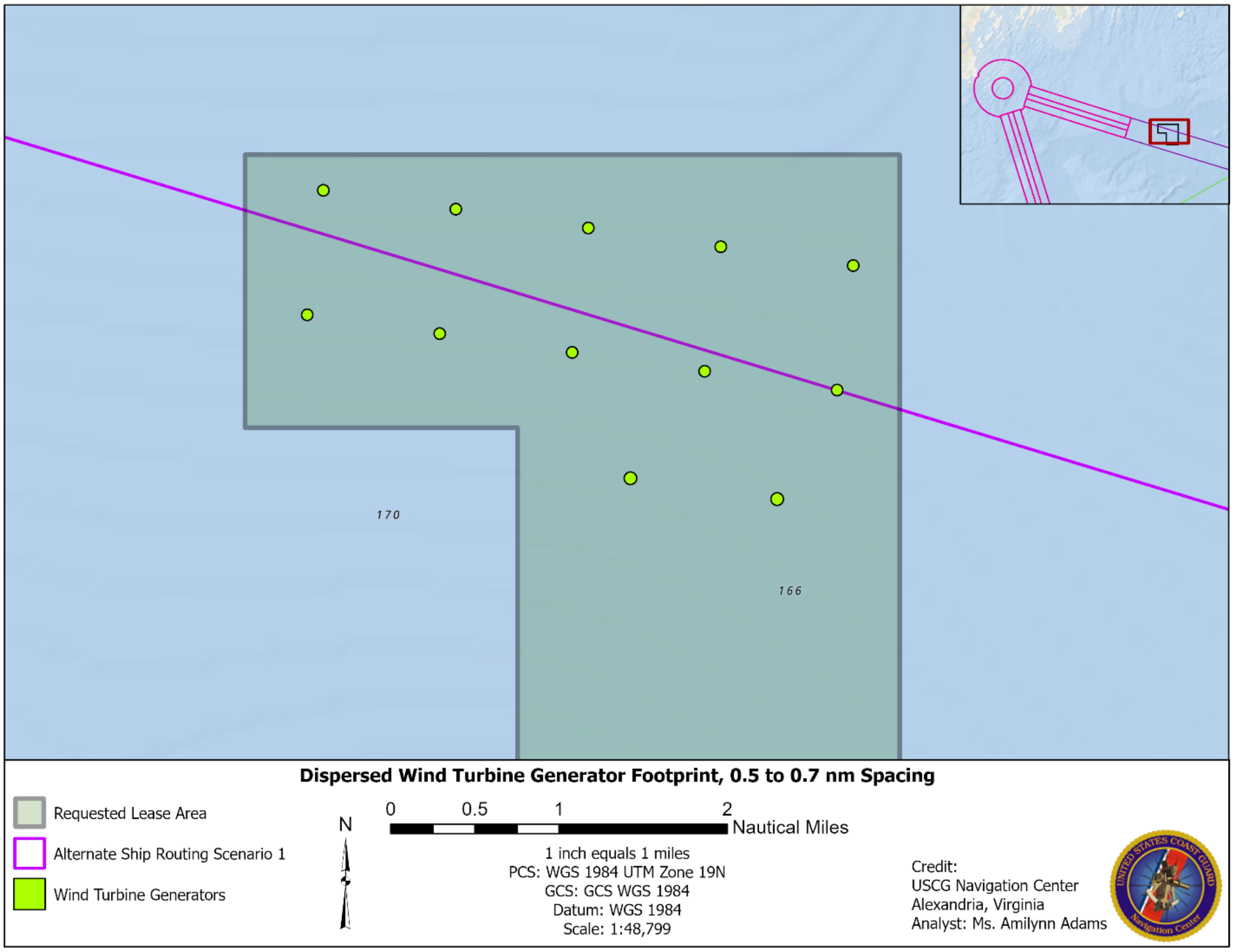


Figure 7-Notional Dispersed Wind Turbine Generator Footprint

Charlie Model Adjustments

Four different traffic scenarios were modeled in the Charlie models:

- Charlie1, No Traffic on SPLIT – the “straight shot” extension of a fairway from the terminus of the current traffic separation scheme.
- Charlie1, Traffic on SPLIT – the “straight shot” extension of a fairway from the terminus of the current traffic separation scheme but including an alternate traffic leg that routes predominantly large passenger ships around the northern side of the Research Array.
- Charlie2 – the “dog leg” which introduced a fairway nearly tangent to the requested lease area.
- Charlie3 – the “eight degree shift” which calls for the clockwise rotation of the traffic separation scheme and the addition of a flared fairway to the end of the traffic separation scheme.

Charlie1, No Traffic on SPLIT Adjustments

Traffic

Vessel traffic contained on the SPLIT leg was transferred to the FW_C1, FW_C2, and FW_C_EXT legs.

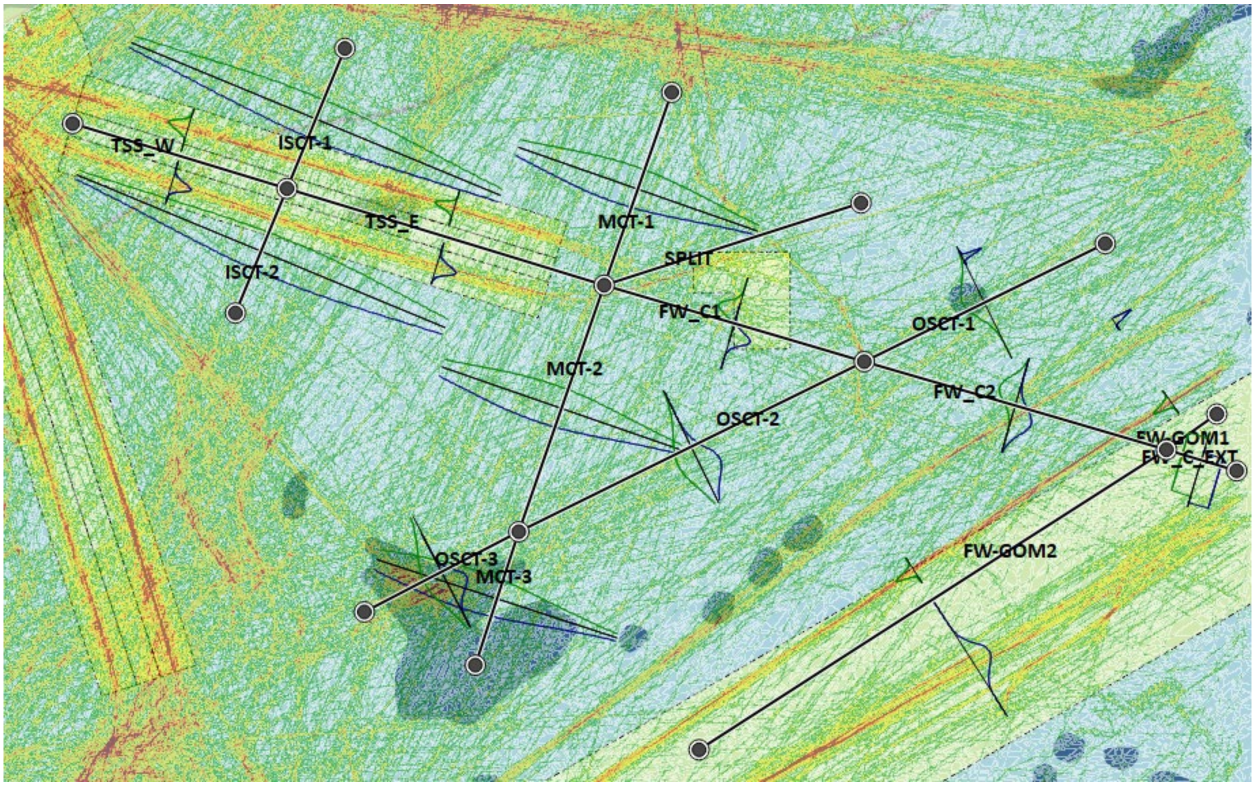


Figure 8-Charlie1, No Traffic on SPLIT Model, source: IWRAP screen grab.

Installations, Facilities, or Structures

The proposed Research Array was added to the Charlie1, No Traffic on SPLIT model using the condensed wind turbine generator footprint.

Charlie1, Traffic on SPLIT Adjustments

Traffic

Vessel traffic contained on the SPLIT leg was modified to transit around the Research Array.

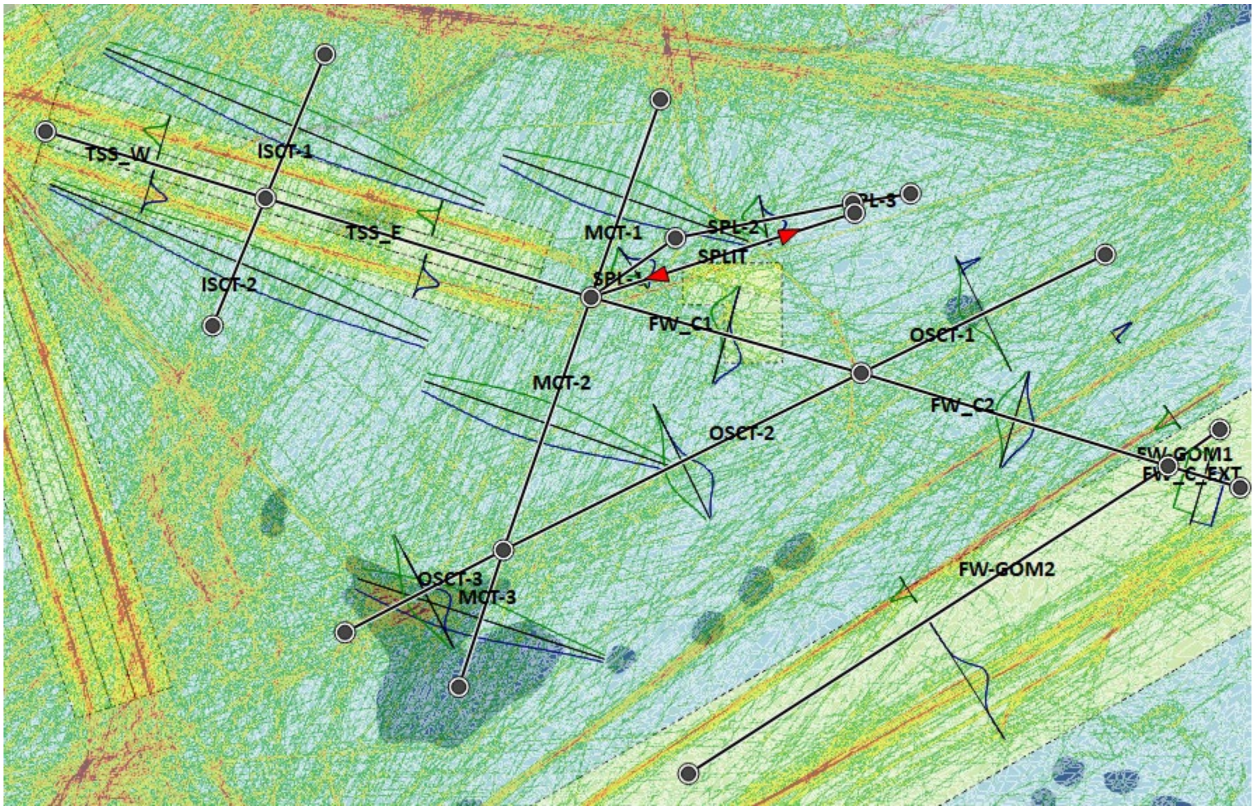


Figure 9-Charlie1, Traffic on SPLIT Model, source: IWRAP screen grab.

Installations, Facilities, or Structures

The proposed Research Array was added to the Charlie2 model using the condensed wind turbine generator footprint.

Charlie2 Adjustments

Traffic

Vessel traffic contained on the SPLIT, FW_C1, FW_C2, and FW_C_EXT legs were shifted to legs B-1, B-2, B-3.

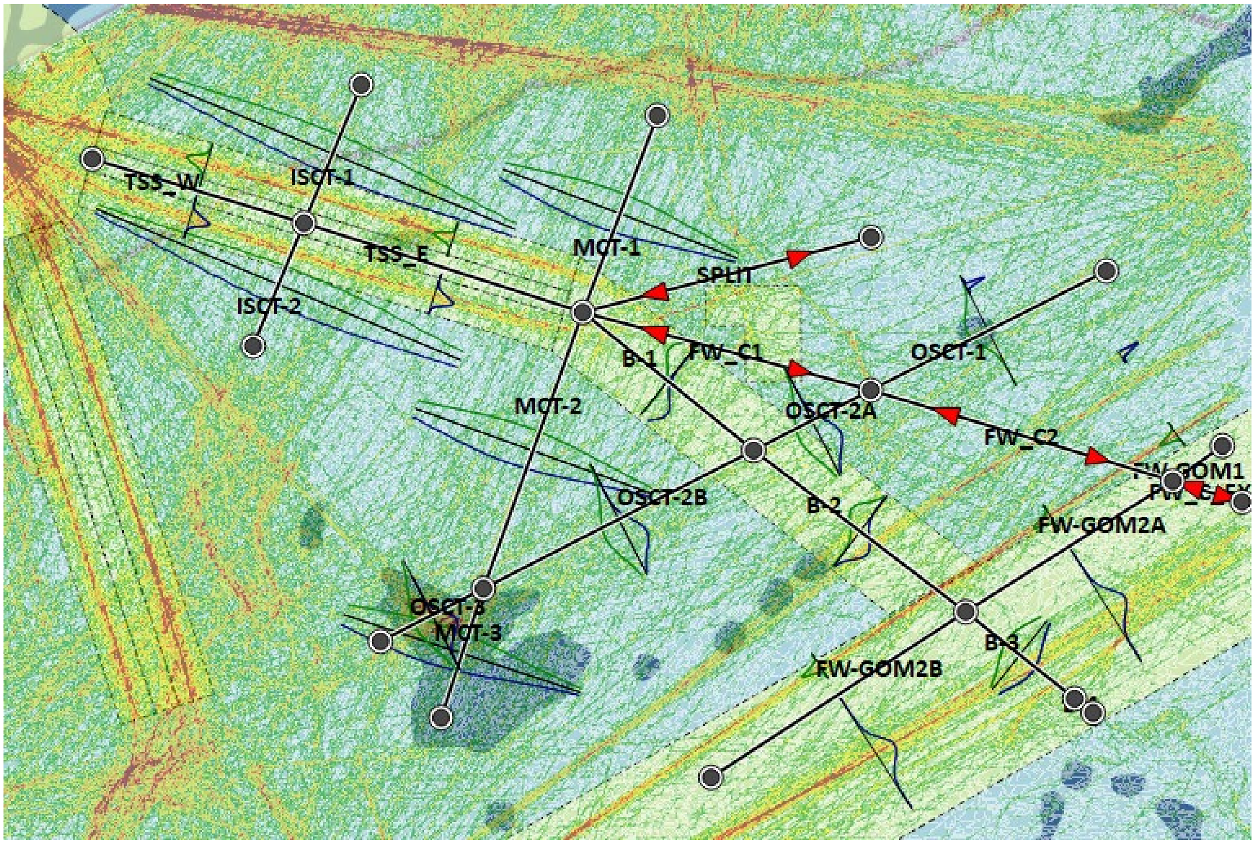


Figure 10-Charlie2 Model, source: IWRAP screen grab.

Installations, Facilities, or Structures

The proposed Research Array was added to the Charlie2 model using the dispersed wind turbine generator footprint.

Charlie3 Adjustments

Traffic

Vessel traffic contained on the TSS_W, TSS_E, SPLIT, FW_C1, FW_C2, and FW_C_EXT legs were shifted to legs TSS-A1, TSS-A2, TSS-A3, TSS-A4, and TSS-A5.

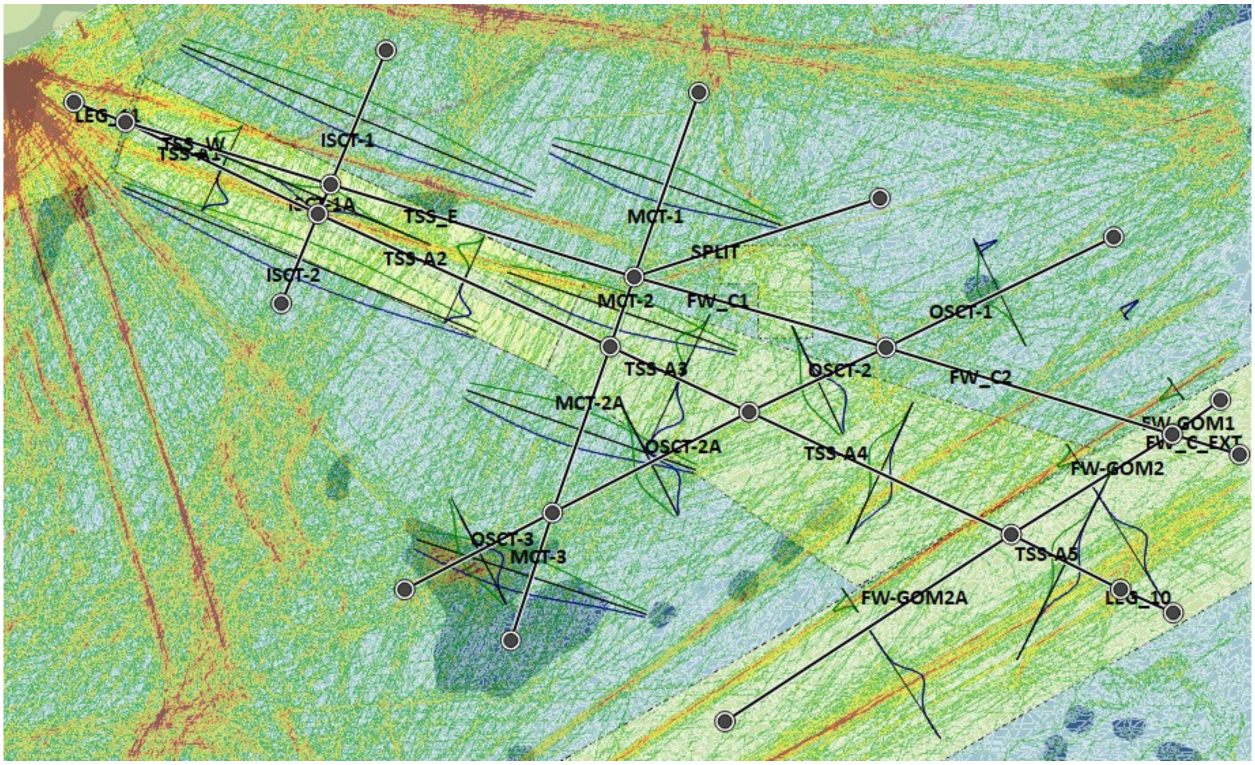


Figure 11-Charlie3 Model, source: IWRAP screen grab.

Installations, Facilities, or Structures

The proposed Research Array was added to the Charlie2 model using the dispersed wind turbine generator footprint.

Results

Maine Research Array, IWRAP Modeling Results
Years between Incidents

	Alpha	Bravo1 Dispersed WTG Footprint	Bravo2 Condensed WTG Footprint	Charlie1 No Traffic on "SPLIT"	Charlie1 Traffic on "SPLIT"	Charlie2	Charlie3
Powered Grounding	---	---	---	---	---	---	---
Drifting Grounding	18,360	18,380	18,380	18,460	18,950	23,190	22,650
Total Groundings	**18,360**	**18,380**	**18,380**	**18,460**	**18,950**	**23,190**	**22,650**
Powered Allision	---	502	647	1,282	1,230	2,738	1,362
Drifting Allision	---	10,030	11,410	10,690	12,510	16,160	25,250
Total Allisions	**---**	**478**	**612**	**1,145**	**1,120**	**2,341**	**1,293**
Overtaking	1,228,000	1,295,000	1,295,000	399,000	408,100	402,000	395,400
HeadOn	636,800	641,300	641,300	1,505,000	1,510,000	1,341,000	1,265,000
Crossing	270,200	186,400	186,400	190,700	132,700	105,300	83,280
Merging	65,530,000	65,530,000	65,530,000	26,460,000	41,840,000	8,711,000	3,699,000
Bend	82,470,000	---	---	107,600,000	3,924,000	4,504,000	131,400,000
Area	---	---	---	---	---	---	---
Total Collisions	**163,600**	**129,700**	**129,700**	**118,200**	**91,510**	**76,540**	**64,080**

Incident Frequency Tolerability

CG NAVCEN Work Instruction 2022-01 provides the following guidance in determining whether a change in predicted incident frequency is tolerable or intolerable:

Intolerable Incident Frequency

An incident frequency is deemed to be intolerable if it is predicted to be less than 100 years between powered allision incidents. If the Alpha (baseline) model incident frequency is less than 100 years between incidents, the Charlie model incident frequency is intolerable when less than the alpha model incident frequency.

Broadly Acceptable Incident Frequency

An incident frequency is deemed to be broadly acceptable if it is predicted to occur less frequently than the baseline incident frequency for each specific or summary incident type in a region. The baseline incident frequency is obtained by probabilistic model via the alpha model run. An incident frequency predicted to occur less than once in 10,000 years (ex, 10,001 years between incidents) is considered broadly acceptable.

Intolerable Change in Incident Frequency

A change between the model incident frequencies is intolerable when the difference of the logarithm of a specific or summary incident frequency is within the bounds of the intolerable and broadly acceptable range and is greater than 0.2. Specifically, where λ is incident frequency of a specific or summary collision, allision, or grounding type expressed in units of years between incidents, an intolerable rate of change in predicted incident frequency is defined as:

$$\log \lambda_{Model\ 1} - \log \lambda_{Model\ 2} \geq 0.2, when\ 100 < \lambda \leq 10{,}000$$

Scenario Tolerability Assessment

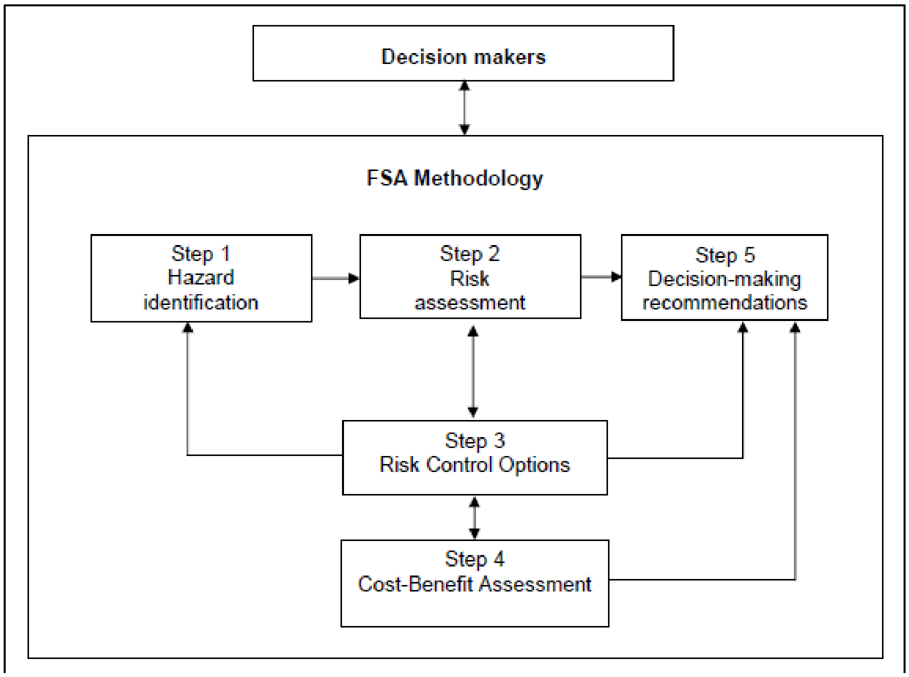
The difference between the summary incident frequency for allisions between the Alpha and Bravo models is:

$$\log Allisions_{Bravo} - \log Allisions_{Alpha}$$
$$\log \infty_{Alpha} - \log 478_{Bravo} = \infty$$
$$\infty \gg 0.2$$

Therefore, a formal safety assessment methodology must be explored, which includes the development of alternate ship routing scenarios amongst other mitigations.

Application of Formal Safety Assessment Methodology

An analysis result designating a category of incident frequency or change in incident frequency as intolerable should trigger steps 3 through 5 of the IMO Formal Safety Assessment process below. The designation of an incident frequency as intolerable or experiencing an intolerable change is not a final or definitive judgment by the USCG regarding the acceptability of a change to a waterway.



Graphic from CG NAVCEN Work Instruction 2022-01 Figure 12-Formal Safety Assessment Methodology Flow Chart

Alternate Ship Routing Scenario Comparative Tolerability

	Bravo, Condensed	Charlie1, No Traffic on "SPLIT"		Charlie1, Traffic on "SPLIT"		Charlie2		Charlie3	
	λ Years/Incident	λ Years/Incident	ΔLog(λ)	λ Years/Incident	ΔLog(λ)	λ Years/Incident	ΔLog(λ)	λ Years/Incident	ΔLog(λ)
Powered Grounding	---	---	Undefined	---	Undefined	---	Undefined	---	Undefined
Drifting Grounding	18,380	18,460	-0.002	18,950	-0.013	23,190	-0.101	22,650	-0.091
Total Groundings	**18,380**	**18,460**	-0.002	**18,950**	-0.013	**23,190**	-0.101	**22,650**	-0.091
Powered Allision	647	1,282	-0.297	1,230	-0.279	2,738	-0.627	1,362	-0.323
Drifting Allision	11,410	10,690	0.028	12,510	-0.040	16,160	-0.151	25,250	-0.345
Total Allisions	**612**	**1,145**	-0.272	**1,120**	-0.262	**2,341**	-0.583	**1,293**	-0.325
Overtaking	1,295,000	399,000	0.511	408,100	0.502	402,000	0.508	395,400	0.515
HeadOn	641,300	1,505,000	-0.370	1,510,000	-0.372	1,341,000	-0.320	1,265,000	-0.295
Crossing	186,400	190,700	-0.010	132,700	0.148	105,300	0.248	83,280	0.350
Merging	65,530,000	26,460,000	0.394	41,840,000	0.195	8,711,000	0.876	3,699,000	1.248
Bend	---	107,600,000	Undefined	3,924,000	---	4,504,000	Undefined	131,400,000	Undefined
Area	---	---	Undefined	---	Undefined	---	Undefined	---	Undefined
Total Collisions	**129,700**	**118,200**	0.040	**91,510**	0.151	**76,540**	0.229	**64,080**	0.306

Figure 14-Comparison of Bravo1 and Charlie Models

	Bravo, Dispersed	Charlie1, No Traffic on "SPLIT"		Charlie1, Traffic on "SPLIT"		Charlie2		Charlie3	
	λ Years/Incident	λ Years/Incident	ΔLog(λ)	λ Years/Incident	ΔLog(λ)	λ Years/Incident	ΔLog(λ)	λ Years/Incident	ΔLog(λ)
Powered Grounding	---	Undefined	Undefined	---	Undefined	---	Undefined	---	Undefined
Drifting Grounding	18,380	18,460	-0.002	18,950	-0.013	23,190	-0.101	22,650	-0.091
Total Groundings	**18,380**	**18,460**	-0.002	**18,950**	-0.013	**23,190**	-0.101	**22,650**	-0.091
Powered Allision	502	1,282	-0.407	1,230	-0.389	2,738	-0.737	1,362	-0.433
Drifting Allision	10,030	10,690	-0.028	12,510	-0.096	16,160	-0.207	25,250	-0.401
Total Allisions	**478**	**1,145**	-0.379	**1,120**	-0.370	**2,341**	-0.690	**1,293**	-0.432
Overtaking	1,295,000	399,000	0.511	408,100	0.502	402,000	0.508	395,400	0.515
HeadOn	641,300	1,505,000	-0.370	1,510,000	-0.372	1,341,000	-0.320	1,265,000	-0.295
Crossing	186,400	190,700	-0.010	132,700	0.148	105,300	0.248	83,280	0.350
Merging	65,530,000	26,460,000	0.394	41,840,000	0.195	8,711,000	0.876	3,699,000	1.248
Bend	---	107,600,000	Undefined	3,924,000	---	4,504,000	Undefined	131,400,000	Undefined
Area	---	---	Undefined	---	Undefined	---	Undefined	---	Undefined
Total Collisions	**129,700**	**118,200**	0.040	**91,510**	0.151	**76,540**	0.229	**64,080**	0.306

Figure 13-Comparison of Bravo2 and Charlie Models

The comparison between the Bravo and Charlie models in Figures 13 and 14 indicates a reduction in the $\Delta \log \lambda$ values (negative values) in the allision incident types. The $\Delta \log \lambda$ increase in the collision incident types within the Charlie models (positive values) is indicative of the impacts of traffic funneling. These increases are deemed to be tolerable due to the incident frequency rate larger than 10,000 years between incidents despite being in excess of the logarithmic difference of 0.2. Note the yellow (between .100 and 0.199 values) values in collisions present in the Charlie1, Traffic on "SPLIT" model. This result is due to the dispersion of traffic along the modified SPLIT leg.

Modelling Errata

IALA Waterways Risk Assessment Program (IWRAP)

The IALA IWRAP is the modeling tool used to develop and evaluate predicted changes in vessel collision, allision, and grounding frequency.

Research Array Structure Inputs

Floating Foundation Size

The Research Array design envelope was obtained and estimated via publicly available documentation describing the planned development. A shapefile representing the floating wind structures was constructed using an assumed circular surface obstruction diameter of 125 meters. This diameter was selected due to the general trend of increasing turbine size/capacity and considering a statement from the State of Maine's Governor's Energy Office which indicated "the floating foundation for each turbine is about 380 feet in diameter – but can vary depending on the final turbine size." [2] It is important to note that the IWRAP model can only consider stationary structures located at the surface of the water. Therefore, any impact of a watch circle or mooring arrangements to deep draft vessels were not included in the model input.

Floating Foundation Footprint

Based on conversations with CG-NAV staff (LCDR Aulner) and experience modeling other wind energy areas, two potential project design envelope floating founding footprints were developed. One footprint was designed to maintain approximately 0.7 to 0.8 nautical mile spacing between the 12 planned wind turbine generators. A condensed footprint was constructed to arrange the 12 planned wind turbine generators within the unencumbered polygon remaining in the Charlie1 model. The condensed footprint provided spacing between approximately 0.5 and 0.7 nautical miles between nearest wind turbine neighbors. These shapefiles were shared with State of Maine contacts (Stephanie Watson and Celina Cunningham) to solicit any constructive input on estimated footprints.

AIS Data

Five-minute aggregate satellite AIS data for the time period from July 1, 2022, to June 30, 2023 were imported to IWRAP and served as the primary vessel activity data source in each modeling

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[2] FAQs: Gulf of Maine Floating Offshore Wind Research Array | Governor's Energy Office

scenario. No additional sources of vessel activity, such as creation of traffic areas to capture historical fishing grounds, were included in the models.

Traffic Areas

Traffic areas were not used in the models. The absence of incident frequencies in this category of collision is due to this omission. Traffic areas are commonly used to define areas where vessels are aggregated and loiter in defined areas, such as fishing vessels or construction vessels.

Additional Details

IWRAP outputs include spatial visualization indicating the range of incident frequency by specific legs, waypoints, contours, and structures. Detailed tabular data outputs describing predicted incident frequency by ship type, collision type, leg, waypoint, structure, and depth contour are available for each model run.

The information provided in this report constitutes summarized outputs intended to assist high-level decision-makers in gaining insight into preliminary draft risk profiles associated with a theoretically proposed Research Array and project design envelope adjacent to a designated shipping safety fairway. This report is not a substitute for any Navigation Safety Risk Assessment requirements. Further analysis is necessary to accurately assess predicted risk factors subsequent to the issuance of a lease and identification of a more precise project design envelope.