CLIMATE CHANGE, SHIPS, & THE BERING SEA:

USING AN OPEN-SOURCE MACHINE LEARNING TOOL TO PREDICT THE FUTURE DISTRIBUTION OF COMMERCIAL FISHING VESSELS

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WHERE WILL COMMERCAIL FISHING VESSELS MOVE IN THE THE FUTURE GIVEN CLIMATE CHANGE?

BACKGROUND

ARCTIC SEA ICE & ALAKSA FISHERIES

- ARCTIC SEA ICE EXTENT DECREASE OF 13.1%/DECADE SINCE 1979 (NASA 2021)
- BENTHIC TEMP. IN THE BERING SEA HAS INCREASED (CHEUNG ET AL. 2010)
- THE BERING SEA ACCOUNTS FOR 30-40% OF ANNUAL COMMERCIAL FISH CATCH IN U.S. (METCALFE ET AL. 2021)
- APPROX. 25-85% OF MARINE SPECIES HAVE ALREADY SHIFTED THEIR GEOGRAPHICAL RANGE (CHEUNG ET AL. 2010)

METHODOLOGY

VESSEL MONITORING SYSTEM DATA

- ON-BOARD TRANSMITTER RELAYS VESSEL'S LOCATION TO NOAA FISHERIES VIA SATELLITE EVERY 30 TO 120 MINUTES
- NOAA MONITORS >4,000 VESSELS 24 HRS/DAYS

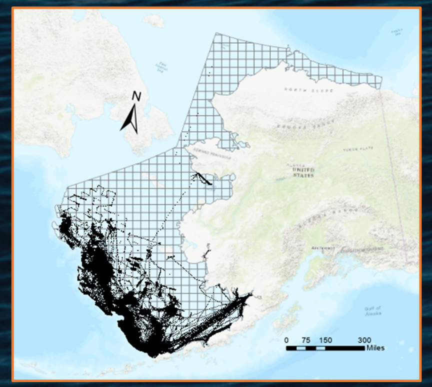

FIGURE 1: EXAMPLE OF VMS VESSEL POSITION REPORTS

MAXIMUM ENTROPY MODELING (MAXENT)

- OPEN-SOURCE MACHINE LEARNING TOOL
  - ORIGINALLY DEVELOPED TO MODEL ENDANGERED SPECIES
- PREDICT FUTURE DISTRIBUTION OF COMMERCIAL FISHING VESSELS IN FUTURE CLIMATE SCENARIOS
- TRAINED TO RECOGNIZE THE COMBINATION OF VARIABLES ASSOCIATED WITH CURRENT (2014) DISTRIBUTION OF FISHING VESSELS
- MARINE RASTER DATA LAYERS FROM BIOORACLE (2000-2014)
- RE-RUN WITH RASTER DATA LAYERS FOR 2100 UNDER DIFFERENT REPRESENTATIVE CONCENTRATION PATHWAYS (RCP)
- PRODUCED RASTERS THAT PROJECTED FISHING VESSEL LOCATION FOR 2100

FIGURE 2: ENVIRONMENTAL VARIABLES USED TO TRAIN MODEL

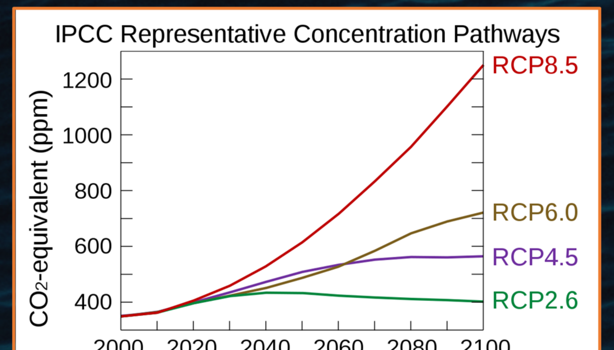

FIGURE 3: CLIMATE MODELS USED FOR 2100: RCP85 MOST PESSIMISTIC & RCP26 MOST OPTIMISTIC

TABLE 1: CONTRIBUTION OF ENVIRONMENTAL VARIABLES FOR CURRENT FISHING VESSEL DISTRIBUTION

Variable	Percent contribution
Surface_ice_thickness	76.3
Surface_salinity	15
Surface_temperature	4.1
Benthic_temperature	3
Benthic_salinity	1.5
Surface_current_velocity	0.1
Benthic_current_velocity	0

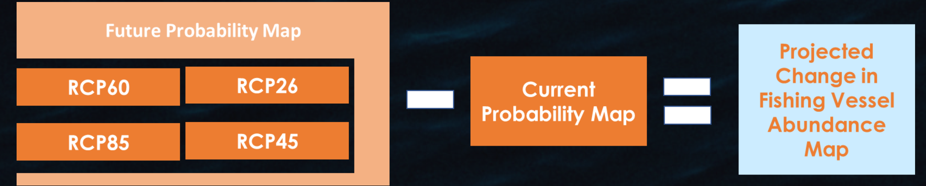

FIGURE 4: RASTER CALCULATOR USED TO VISUALIZE AREAS OF FISHING VESSEL CHANGE AND ABUNDANCE

RESULTS

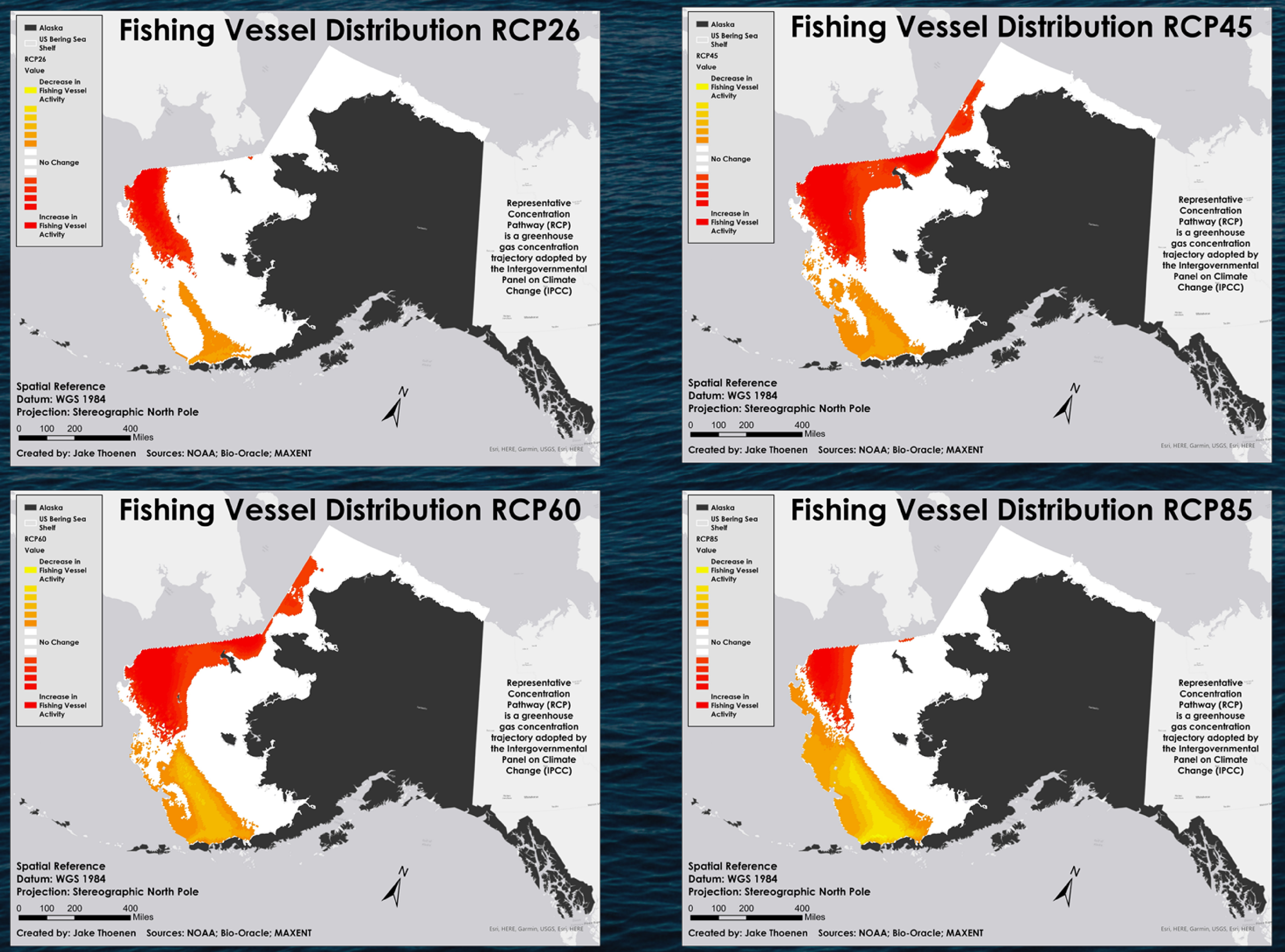

FIGURE 5: PROJECTED CHANGE IN FISHING VESSEL DISTRIBUTION FROM 2014 TO 2100 GIVEN RCP: 2.6, 4.5, 6.0, & 8.5

RANGE OF ACTION

WHAT ARE THE IMPLICATIONS FOR COAST GUARD OPERATIONS IN THE BERING SEA?

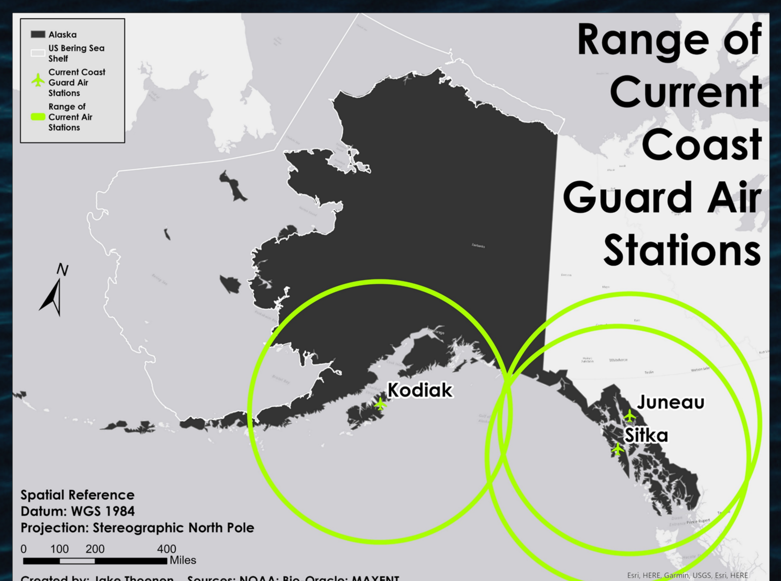

FIGURE 6: RANGE OF CURRENT COAST GUARD AIR STATIONS GIVEN THE RANGE OF ACTION OF MH-60T (JAYHAWK) HELO

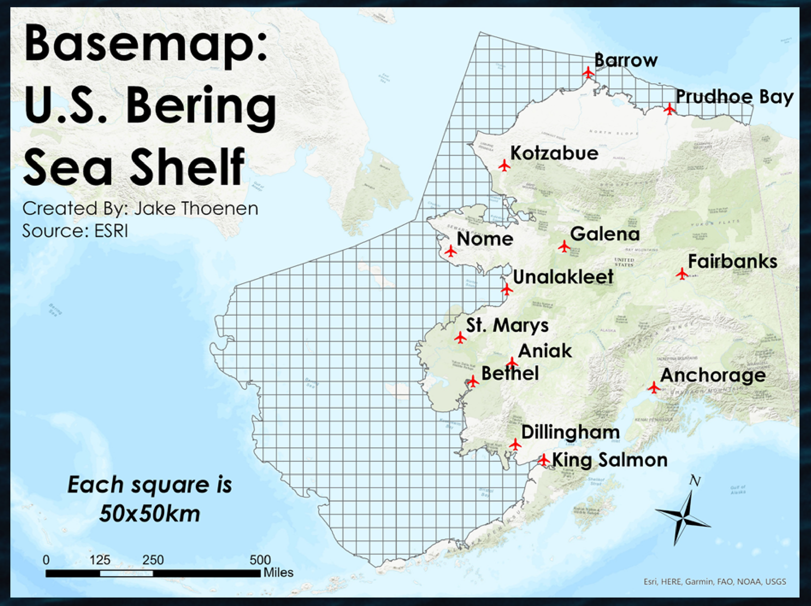

FIGURE 7: LOCATIONS OF COAST GUARD ASSETS IN THE PAST EQUIPPED FOR AIR STATION CAPABILITIES

- Create range for each potential station based on MH-60T HELO
- Extract positive values of each climate model
- Calculate % coverage and sum of probability
- Determine best CG AIRSTA location for each climate model

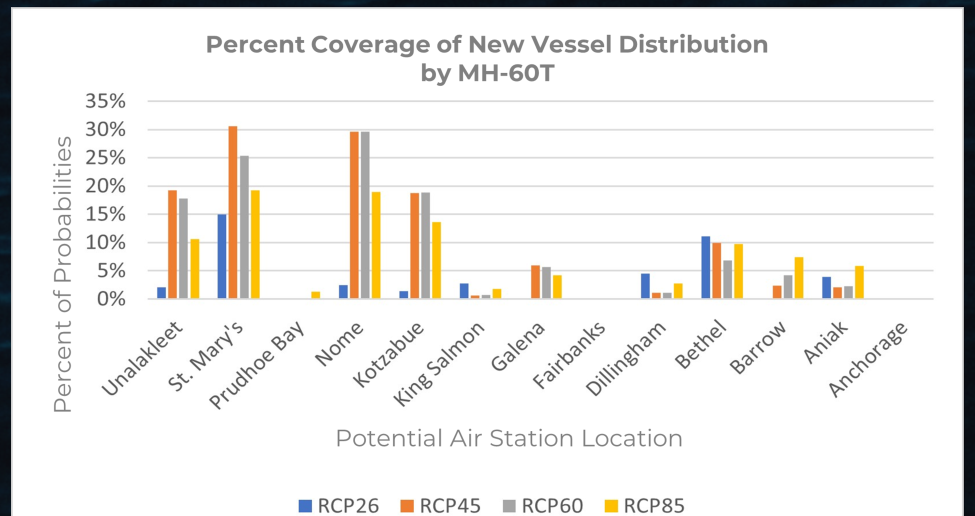

FIGURE 8: PERCENT COVERAGE OF FUTURE VESSEL DISTRIBUTION BY MH-60T RANGE OF ACTION

NEW AIR STATION LOCATIONS

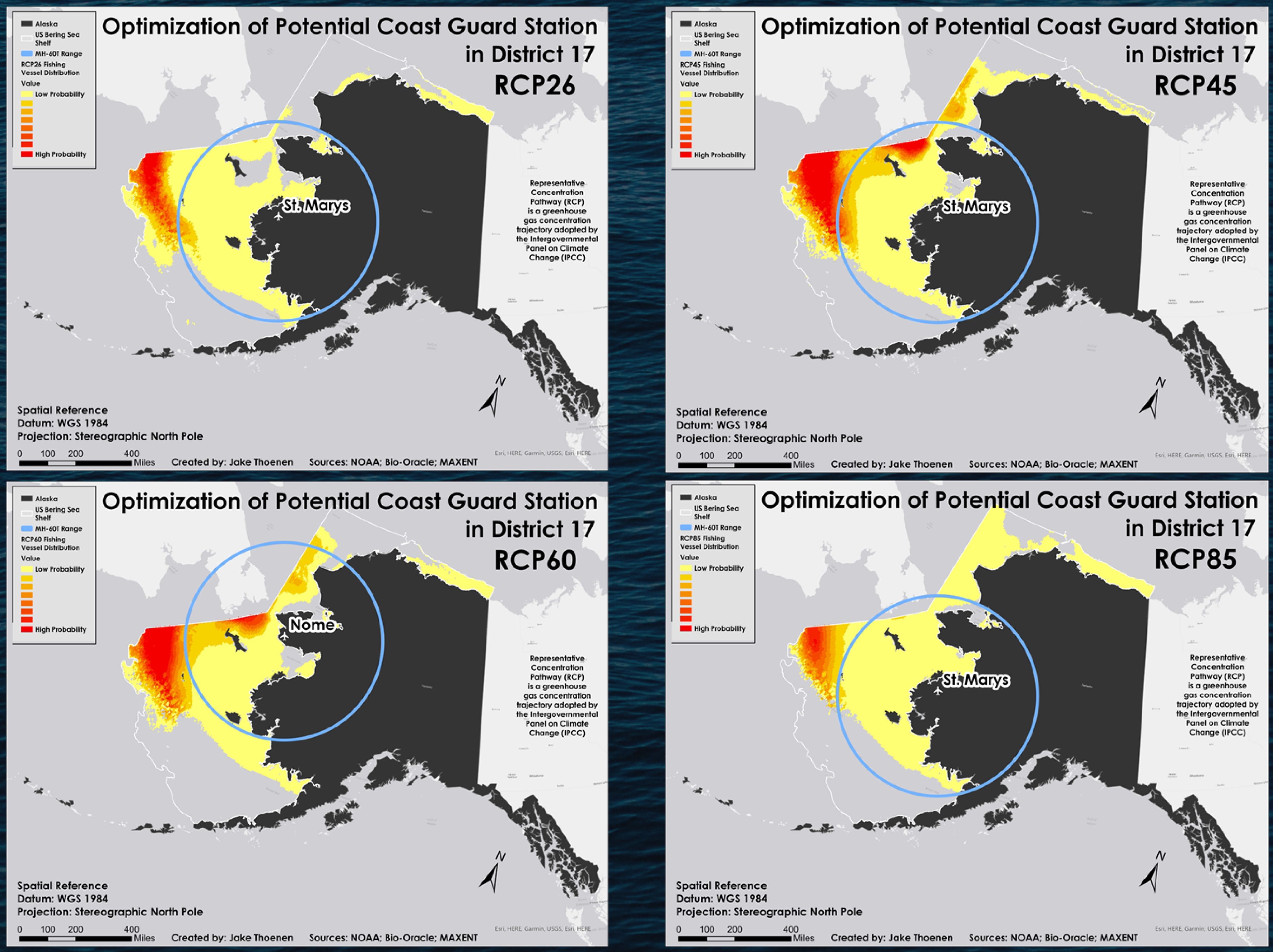

FIGURE 9: BEST LOCATIONS FOR A NEW COAST GUARD AIR STATION GIVEN FUTURE DISTRIBUTION OF COMMERCIAL FISHING VESSELS USING CLIMATE MODELS FOR 2100

DISCUSSION

In all climate scenarios, commercial fishing vessels are projected to move further northwest by 2100

The Coast Guard needs to reallocate assets to optimize mission success in light of climate change in the Arctic

- Oil Spill Response
- Fisheries Enforcement
- Search & Rescue

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