Use of MARXAN as a Planning Tool for the MLPA North Central Coast Study Region Bren School of Environmental Science and Management[1]

This analysis was designed to assist regional stakeholder group (RSG) planning of marine protected areas (MPAs) to meet the goals and objectives of the Marine Life Protection Act (MLPA) in the MLPA North Central Coast Study Region. A master thesis group from the UCSB Bren School used MARXAN, a marine reserve design software tool to identify areas that best meet specific goals. As an optimization tool, MARXAN can identify planning units that meet habitat protection goals, while minimizing potential socioeconomic costs (gauged as either total area of the network of marine reserves or commercial fishing effort).

What kind of data did we use for this analysis?
We used the same habitat features (and spatial data layers) that the RSG and MLPA Master Plan Science Advisory Team (SAT) are considering for the north central coast [such as rocky intertidal habitat, rocky reef (0-30m, 30-100m) kelp forest, eelgrass, sandy bottom, etc.] in three bioregions (north, south, and Farallon Islands). For planning purposes, we divided the study region into half minute square planning units, which are approximately 0.5 x 0.5 square nautical miles.

We used the Ecotrust survey commercial fishing data on areas of importance for 34 fisheries in the study region. These data were aggregated across 34 fisheries and converted into an index value to indicate the relative importance of each planning unit to commercial fishermen. Each fishery was weighted based on the revenue of the entire regional fishery, giving more weight to the more lucrative fisheries. A value of 1 was assigned to the most important fishing grounds of the most valuable fishery.

What do the MARXAN maps show?
These maps show the number of times each planning unit (a 0.5 x 0.5 minute block) was included in the outputs of a computer model attempting to achieve a specified habitat representation goal while minimizing area. The maps do not show MPA locations or recommendations for MPA locations. Rather, they show planning units where it is most like the habitat goals will be achieved given the model inputs.

Purple planning units were included in a modeled result in all 100 of the best runs, red planning units were included in 81-99% of the 100 best model runs, orange planning units were selected in 61-80%, yellow planning units were selected in 41-60%, green planning units were selected in 21-40%, and blue planning units were selected in 1-20%. White planning units were not selected in any of the 100 best runs. It is important to note that white planning units should not be considered "useless". Rather, these locations are less likely to achieve the specified goal in an efficient manner. The more frequently selected planning units represent locations where multiple portions of the goals are met in an efficient way.

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[1] MLPA Group Thesis Project. James Anderson, Cheryl Chen, Emily Frost, Jessica Spence, and Meghan Sullivan. December 11, 2007

Figures 1a, 1b, and 1c. Biophysical Data
These maps are useful for visualizing locations in the study region that most efficiently meet the habitat representation goals in the smallest amount of area. For this analysis, the planning tool identified planning units that would include 10%, 17%, and 34% of all marine habitat types for which data are available in study region. Percentage goals were selected based on a combination of the size and spacing guidelines provided by the SAT (see below). We assumed that the "cost" of including each planning unit was equal, without considering other economic costs. MARXAN identifies planning units which meet habitat goals at a minimum cost, in this case, minimum total area.

Figures 2a, 2b, and 2c. Biophysical Data and Commercial Fishing Effort
We performed an additional analysis in which we incorporated data on the amount of commercial fishing effort present in the planning region (Ecotrust data). As with the biophysical only analysis, the planning tool identified planning units that would capture 10%, 17%, or 34% of all marine habitat types. In contrast to the previous analysis, this set of model runs also sought to minimize the cost to commercial fisheries at the same time. This "optimization" of tradeoffs between biophysical and economic goals is the hallmark of the MARXAN tool.

Figure 3. 10% Cost Threshold
In the third analysis, the model identified planning units that would conserve all (or as much as possible) habitat types, while limiting the potential impact to any commercial fishery to 10%. It should be noted that none of the solutions satisfied all of the constraints. The conservation targets were set at 100% in order to identify the maximum amount of each conservation target that could be preserved while displacing no more than 10% of commercial fishing effort.

Why did we select 10%, 17% and 34% as conservation targets?
MARXAN requires inputs on the amount of a given feature (in this case habitat types) to attempt to protect. For instance, at the 10% conservation target, each MARXAN output must include 10% of each of the habitats in the region.

The range of conservation targets were derived from the science guidelines for size and spacing: With a minimum size recommendation of 3 miles, a preferred size of 12.5 miles, a minimum spacing of 31 miles, and a maximum spacing of 62 miles. If the minimum size and minimum spacing are used to design a network of MPAs, the total area set aside would be approximately 10% of the study area, assuming habitats are distributed evenly. If the preferred size and maximum spacing were used, the total area set aside would be approximately 17% and if the preferred size and minimum spacing were used, then the total area set aside would be approximately 34%.

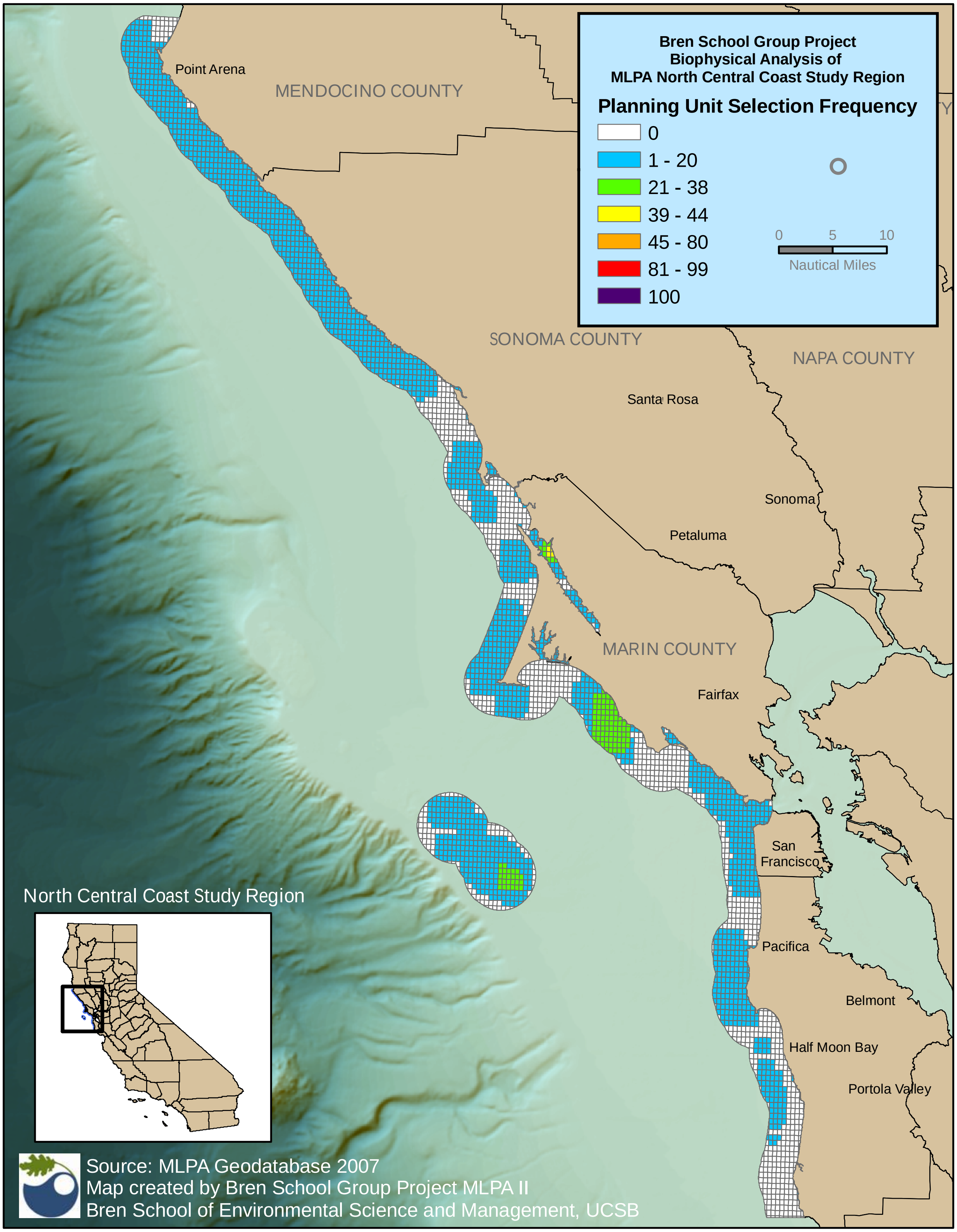
There are many good solutions to the problem of where to establish marine protected areas. Because there are many possible solutions to the problem, each run of the MARXAN model is different. Some places, with unique characteristics or rare features, are selected in many different runs. But other conservation features may be common and could be protected in many different places. The exact planning units identified varies with each run and the total area of the output also varies somewhat. For this analysis, MARXAN was run 1000 times for each conservation target (10%, 17% and 34%). We selected the 100 runs with the "best scores" (i.e. solutions that meet all conservation targets while minimizing network area). We overlaid the top 100 runs to create maps that show the number of times each planning unit was selected in a final solution.

Who We Are:
This analysis is part of a Group Thesis Project that will be completed in partial fulfillment of a Masters Degree in Environmental Science and Management at the Bren School of Environmental Science and Management. We are five Master's students working collaboratively on decision support tools and analyses to support the Marine Life Protection Act North Central Coast Project. Our intention is to provide unbiased, science-based products to inform north central coast stakeholders and SAT members and assist the North Central Coast Project of the MLPA Initiative to reach the best possible decisions. If you have any questions about the project or would like more information about our research, please contact us at: mlpa2@bren.ucsb.edu.

MARXAN Summed Solution

Figure 1A: Planning Unit Occurrence Summary Using Low Habitat Goals as a Conservation Target

12/03/2007

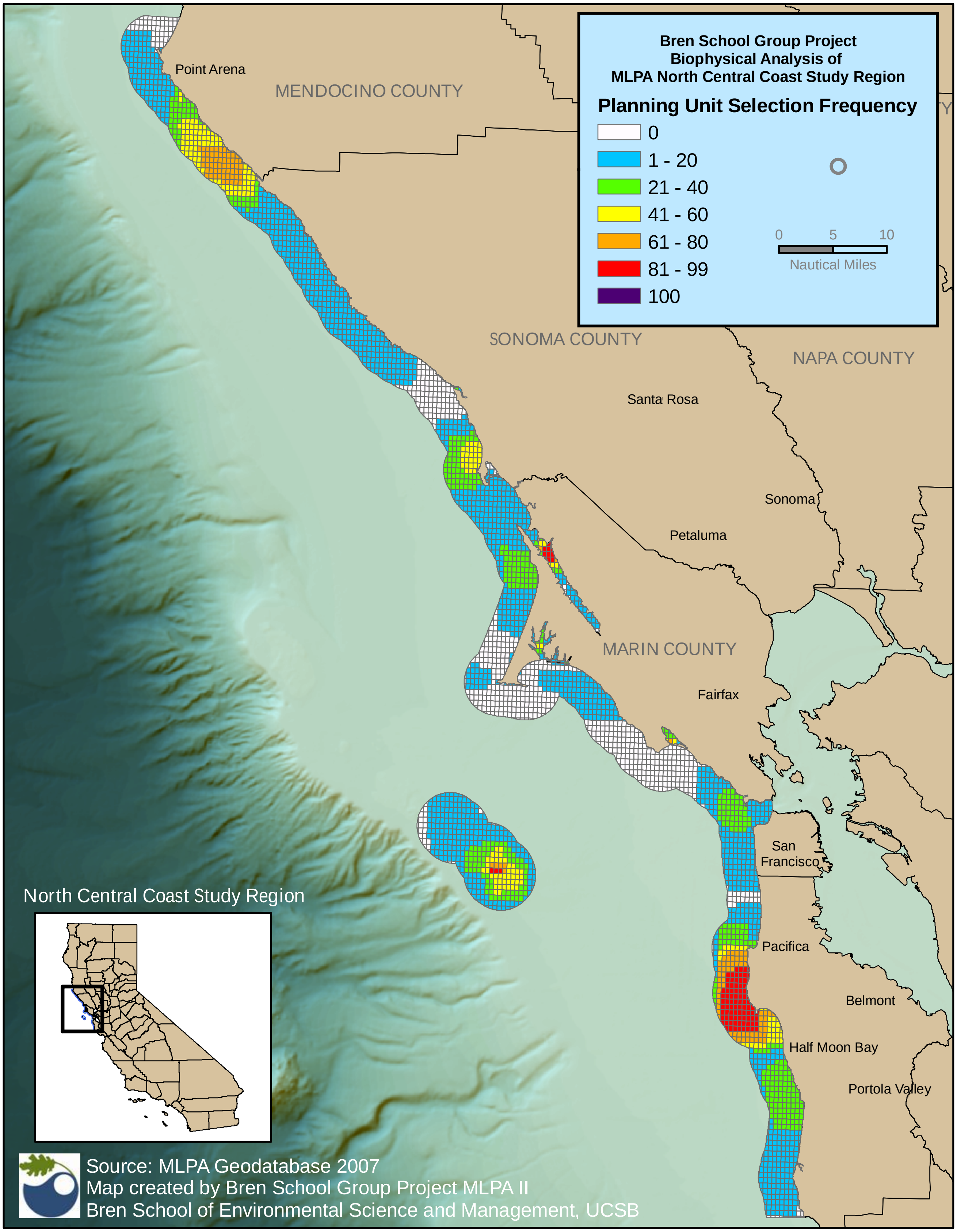


The purpose of this exercise was to show areas that conserve 10% of each key habitat.This map depicts the results of a biophysical analysis using the conservation planning tool MARXAN and the best available marine habitat data. Half-minute planning units, the most efficient boundary length modifier (BLM), which in this case was 0.003, and a target of 10% representative habitat conservation were used. The algorithm was run 1000 times and then the 100 “best” runs were overlaid to identify planning units with potentially high biophysical conservation value.

MARXAN Summed Solution

Figure 1B: Planning Unit Occurrence Summary Using Moderate Habitat Goals as a Conservation Target

12/03/2007

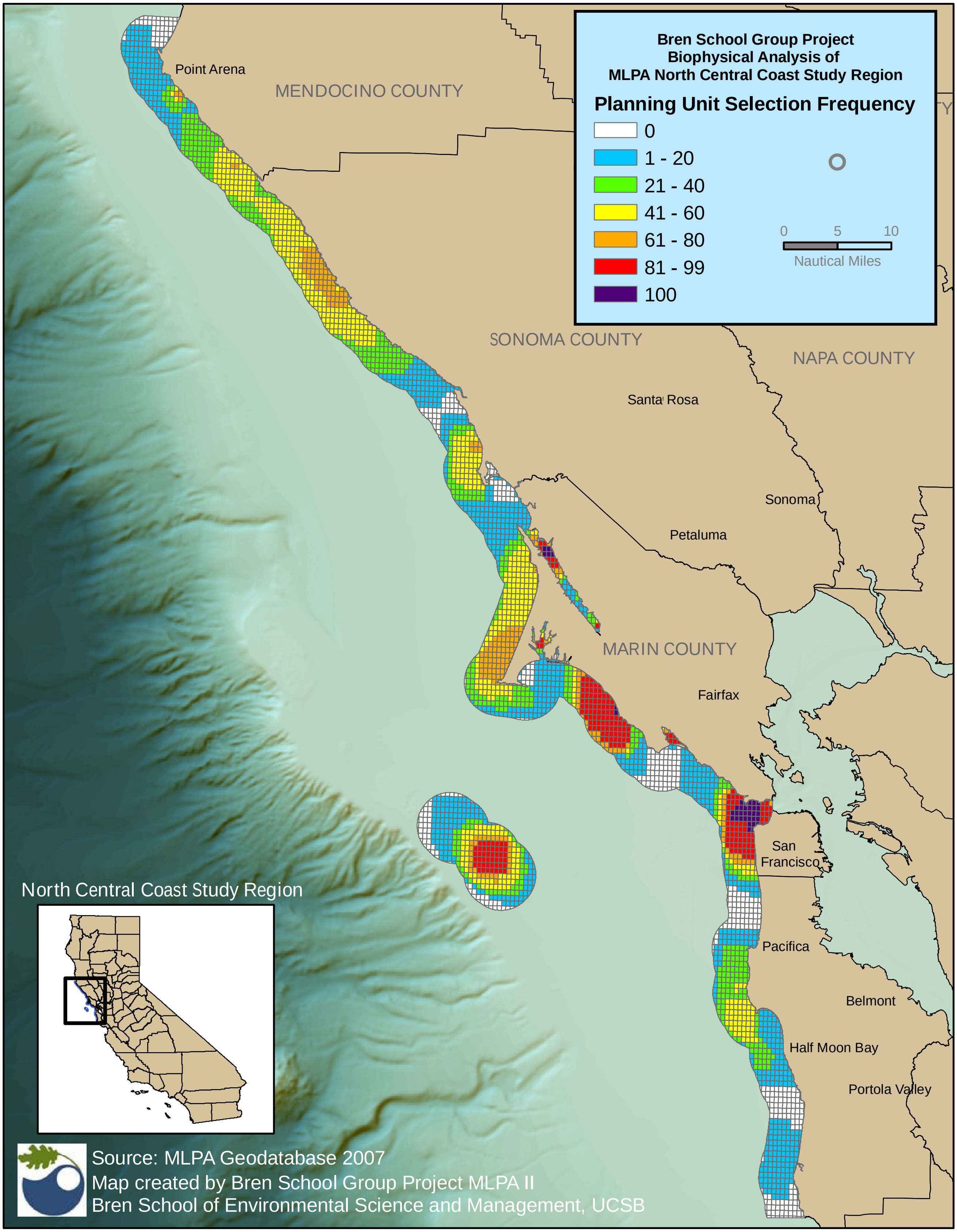


The purpose of this exercise was to show areas that conserve 17% of each key habitat.This map depicts the results of a biophysical analysis using the conservation planning tool MARXAN and the best available marine habitat data. Half-minute planning units, the most efficient boundary length modifier (BLM), which in this case was 0.003, and a target of 17% representative habitat conservation were used. The algorithm was run 1000 times and then the 100 “best” runs were overlaid to identify planning units with potentially high biophysical conservation value.

MARXAN Summed Solution

Figure 1C: Planning Unit Occurrence Summary Using High Habitat Goals as a Conservation Target

12/03/2007

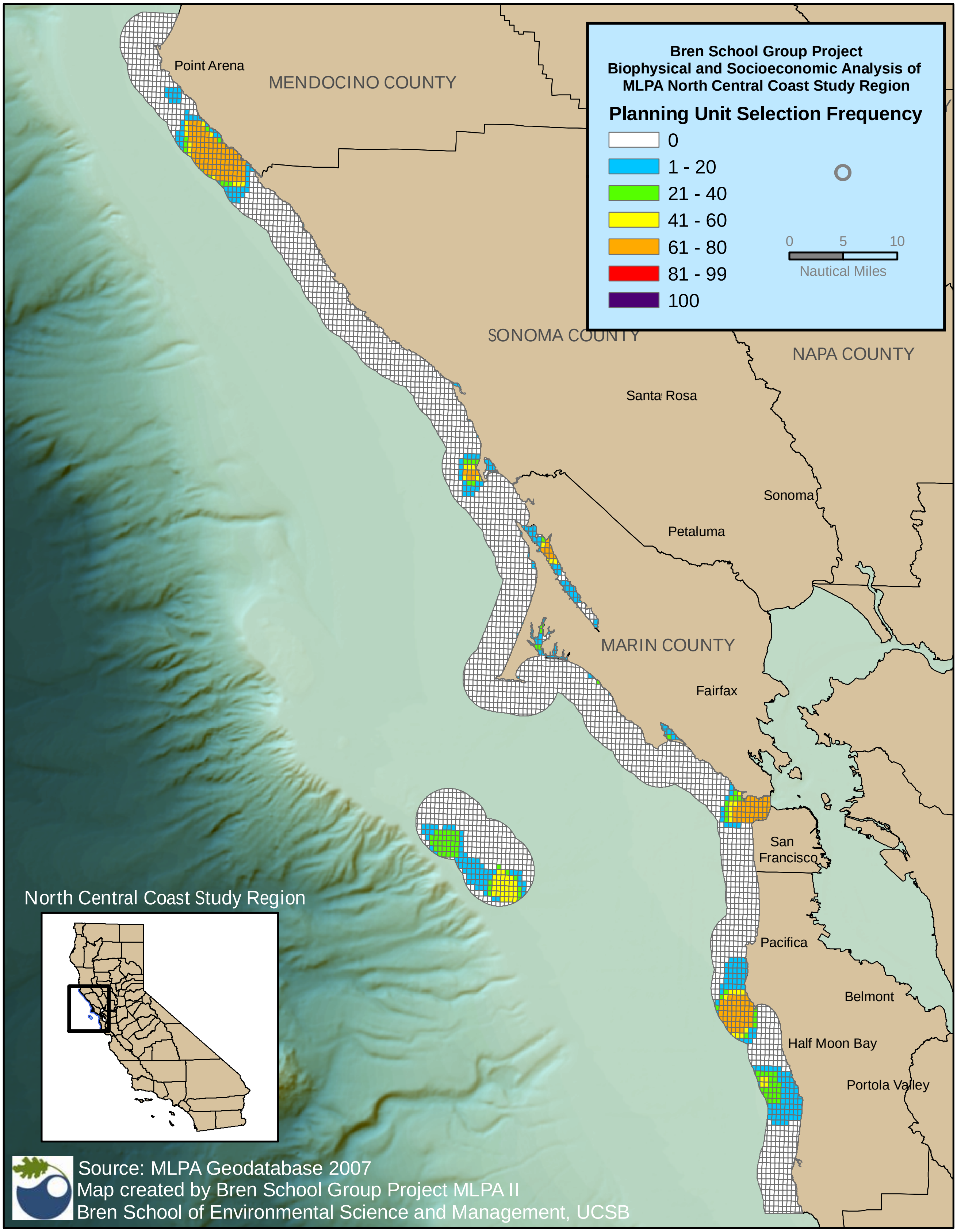


The purpose of this exercise was to show areas that conserve 34% of each key habitat. This map depicts the results of a biophysical analysis using the conservation planning tool MARXAN and the best available marine habitat data. Half-minute planning units, the most efficient boundary length modifier (BLM), which in this case was 0.003, and a target of 34% representative habitat conservation were used. The algorithm was run 1000 times and then the 100 “best” runs were overlaid to identify planning units with potentially high biophysical conservation value.

MARXAN Summed Solution

Figure 2A: Planning Unit Occurrence Summary Using Low Habitat Goals as a Conservation Target and Minimization of Commercial Fishery Impact as a Socioeconomic Target

12/03/07

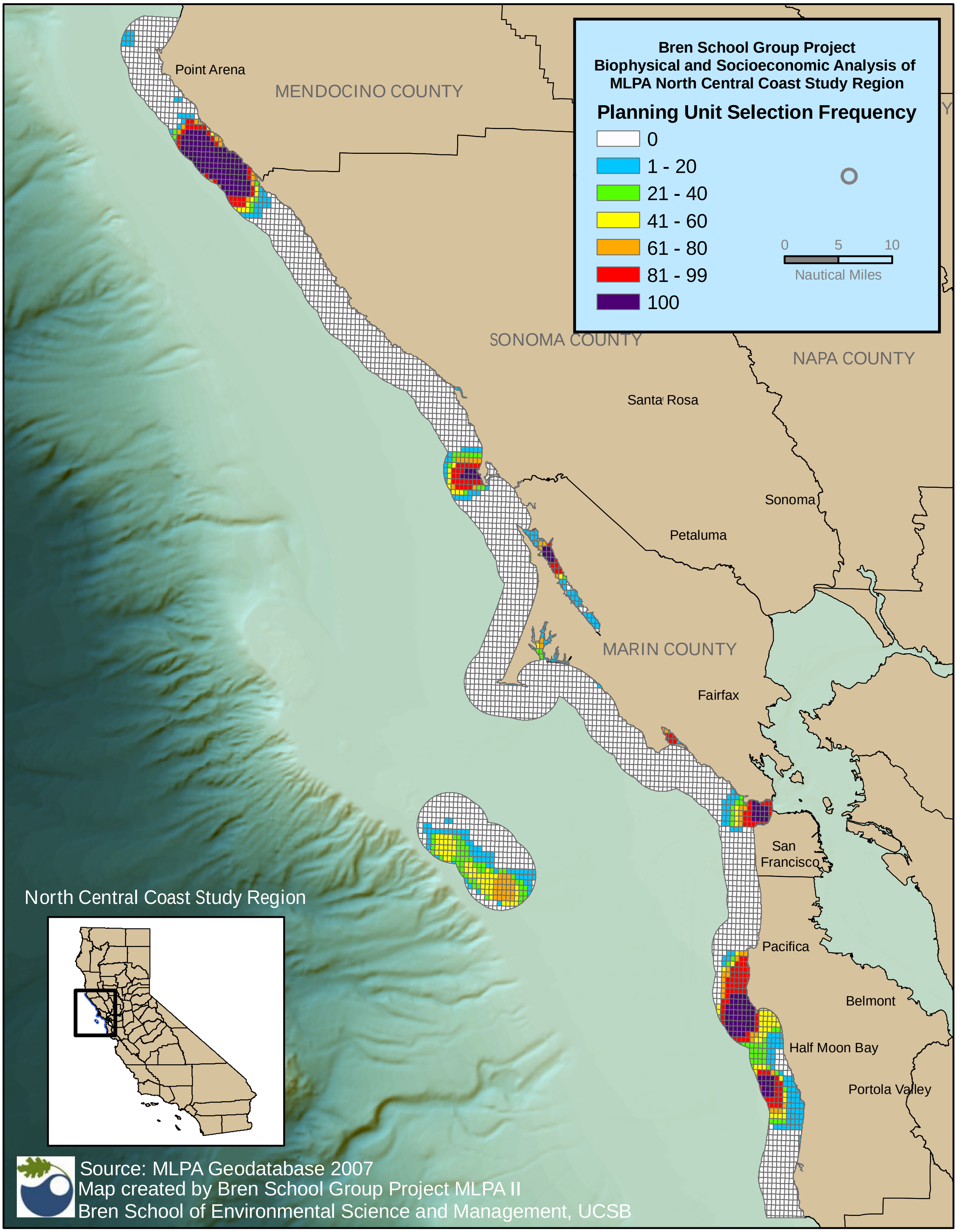


The purpose of this exercise was to conserve 10% of key habitats while minimizing the cost to the fisheries. This map depicts the results of a biophysical and socioeconomic (costs to commerical fisheries) analysis using the conservation planning tool MARXAN and the best available data. Half-minute planning units, the most efficient boundary length modifier (BLM), which in this case was 0.0001, and a target of 10% representative habitat conservation were used. The algorithm was run 1000 times and then the 100 "best" runs were overlaid to identify planning units with potentially high biophysical and socioeconomic conservation value that considers costs to commerical fisheries.

MARXAN Summed Solution

Figure 2B: Planning Unit Occurrence Summary Using Moderate Habitat Goals as a Conservation Target and Minimization of Commercial Fishery Impact as a Socioeconomic Target

12/03/2007

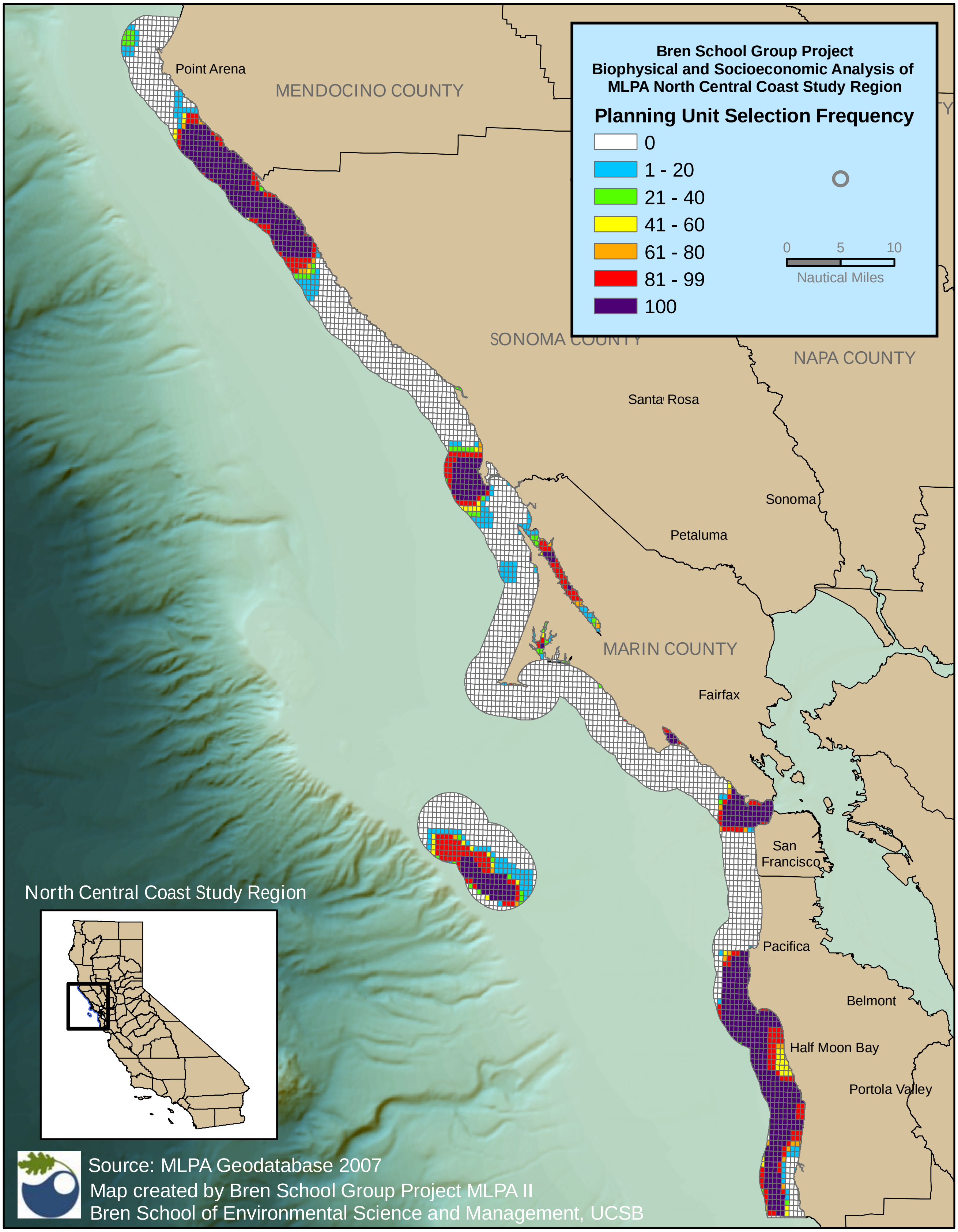


The purpose of this exercise was to conserve 17% of key habitats while minimizing the cost to the fisheries. This map depicts the results of a biophysical and socioeconomic (costs to commerical fisheries) analysis using the conservation planning tool MARXAN and the best available marine habitat data. Half-minute planning units, the most efficient boundary length modifier (BLM), which in this case was 0.0001, and a target of 17% representative habitat conservation were used. The algorithm was run 1000 times and then the 100 "best" runs were overlaid to identify planning units with potentially high biophysical and socioeconomic conservation value that considers cost to commercial fisheries.

MARXAN Summed Solution

Figure 2C: Planning Unit Occurrence Summary Using High Habitat Goals as a Conservation Target and Minimization of Commercial Fishery Impact as a Socioeconomic Target

12/03/2007

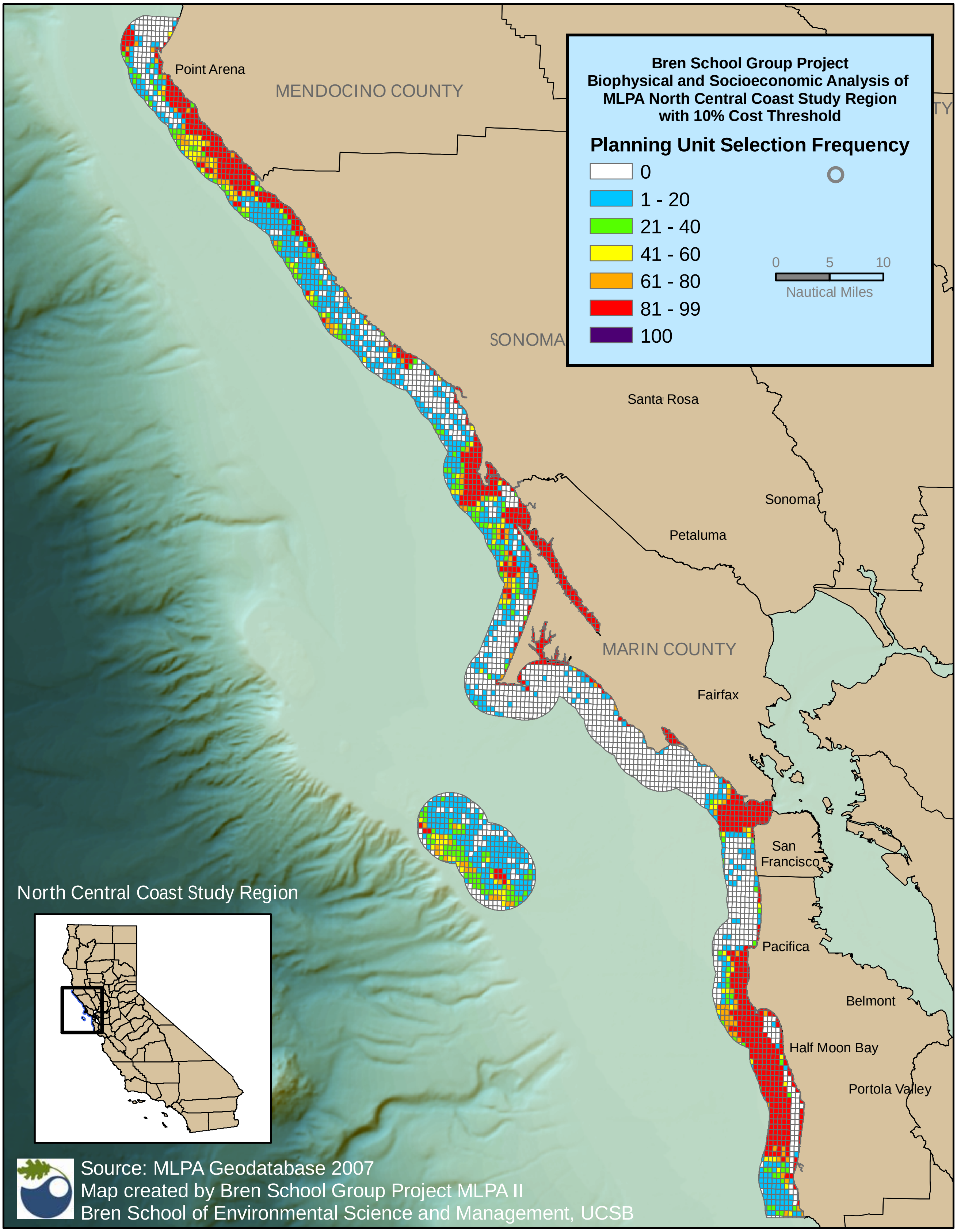


The purpose of this exercise was to conserve 34% of key habitats while minimizing the cost to the fisheries. This map depicts the results of a biophysical and socioeconomic (costs to commerical fisheries) analysis using the conservation planning tool MARXAN and the best available marine habitat data. Half-minute planning units, the most efficient boundary length modifier (BLM), which in this case was 0.0001, and a target of 34% representative habitat conservation were used. The algorithm was run 1000 times and then the 100 “best” runs were overlaid to identify planning units with potentially high biophysical and socioeconomic conservation value that considers cost to commercial fisheries.

MARXAN Summed Solution

Figure 3: Planning Unit Occurrence Summary Using 100% Conservation Targets and a 10% Cost Threshold as a Socioeconomic Target

12/03/2007



The purpose of this exercise was to find the best solutions based on limiting the cost to the commercial fisheries in the North Central Coast study region to 10% of the total cost with the conservation targets set at 100%.This map depicts the results of a biophysical and socioeconomic (costs to commerical fisheries) cost threshold analysis using the conservation planning tool MARXAN and the best available marine habitat data. Half-minute planning units, the most efficient boundary length modifier (BLM), which in this case was 0.0001, and a target of 100% representative habitat conservation were used. The algorithm was run 1000 times and then the 100 “best” runs were overlaid to identify planning units with only a cost of 10% to commercial fisheries.