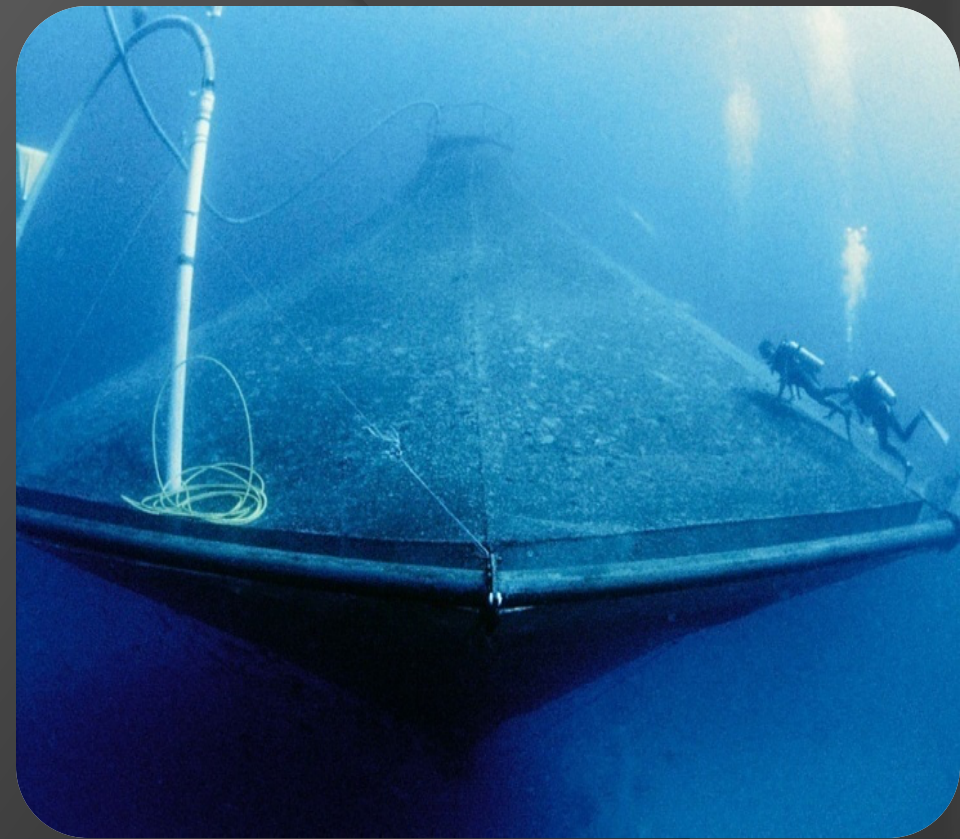# A REGIONAL SCALE SITE SUITABILITY FRAMEWORK FOR AQUACULTURE IN OFFSHORE ZONES; A CASE STUDY ON O'AHU, HAWAI'I

AWOC, Hakodate, Japan, December 18-20
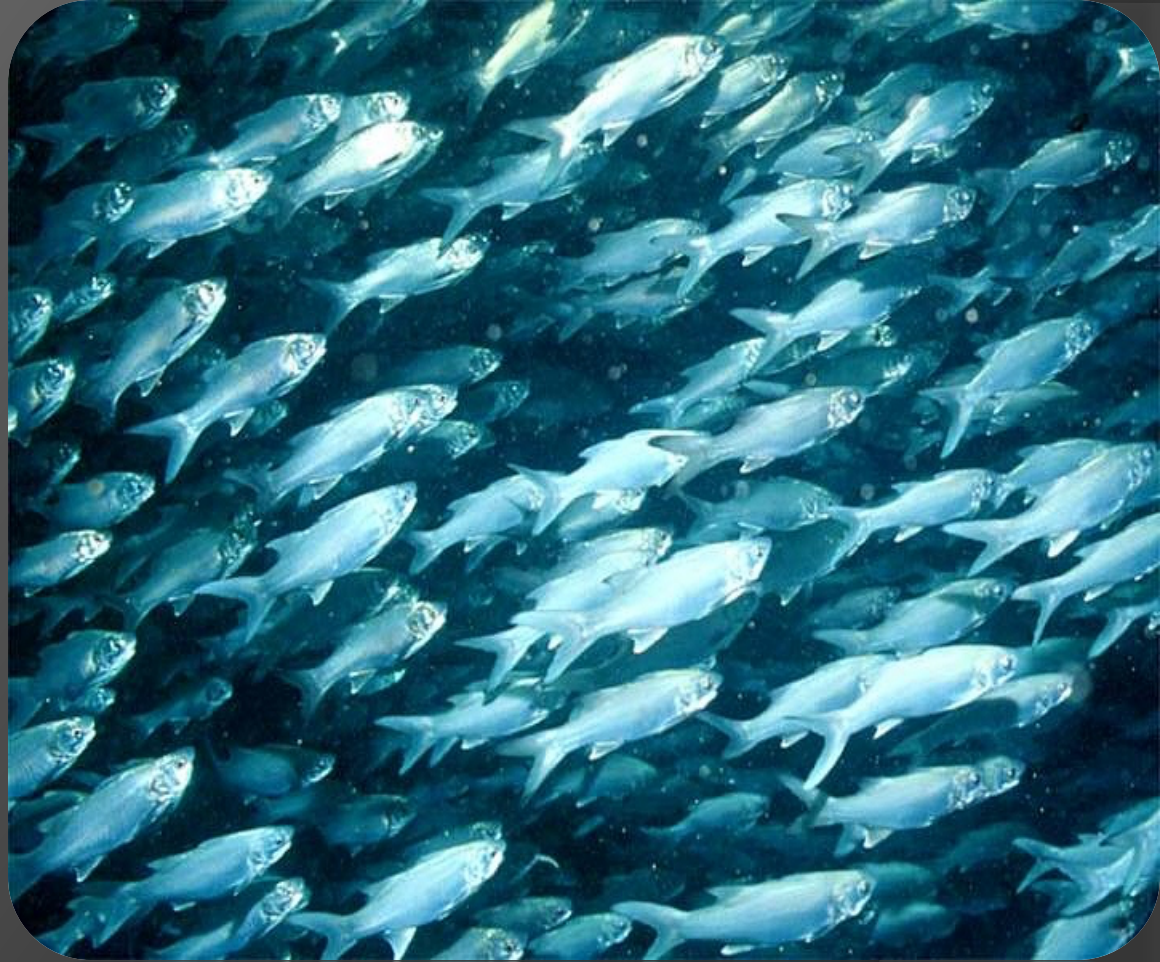**oberding@hawaii.edu**

Tomáš Jan Oberding, Carl Evensen, PingSun Leung, Michael Robotham, Brian Szuster, Clyde Tamaru

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Topics

- Introduction
  - Problem
  - *History*
  - Selection v Suitability
  - Objective
- Frameworks
  - Basic
  - Environmental
  - Economic
  - Social
  - Combined
- Conclusions
- Questions?

Introduction

Statement of Problem

- Siting issues worldwide & Hawai'i
  - Environmental, cultural issues, economics

- Goal:
  - Bridge environmental, economic, and social
  - Increase aquaculture production
    - Lessen demand on wild stocks

- How?
  - Simple Multi-Criteria Decision Making Model

A Bit
of
History

Why Offshore?

- 1800, 230 ponds: >1.5 millions #s
- 1990, 6 ponds: 31,639 pounds/year
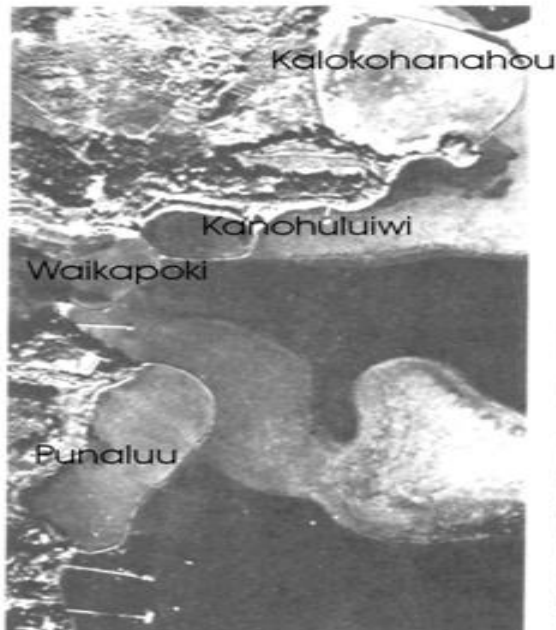
a. 1928   b. 1949   c. 1971
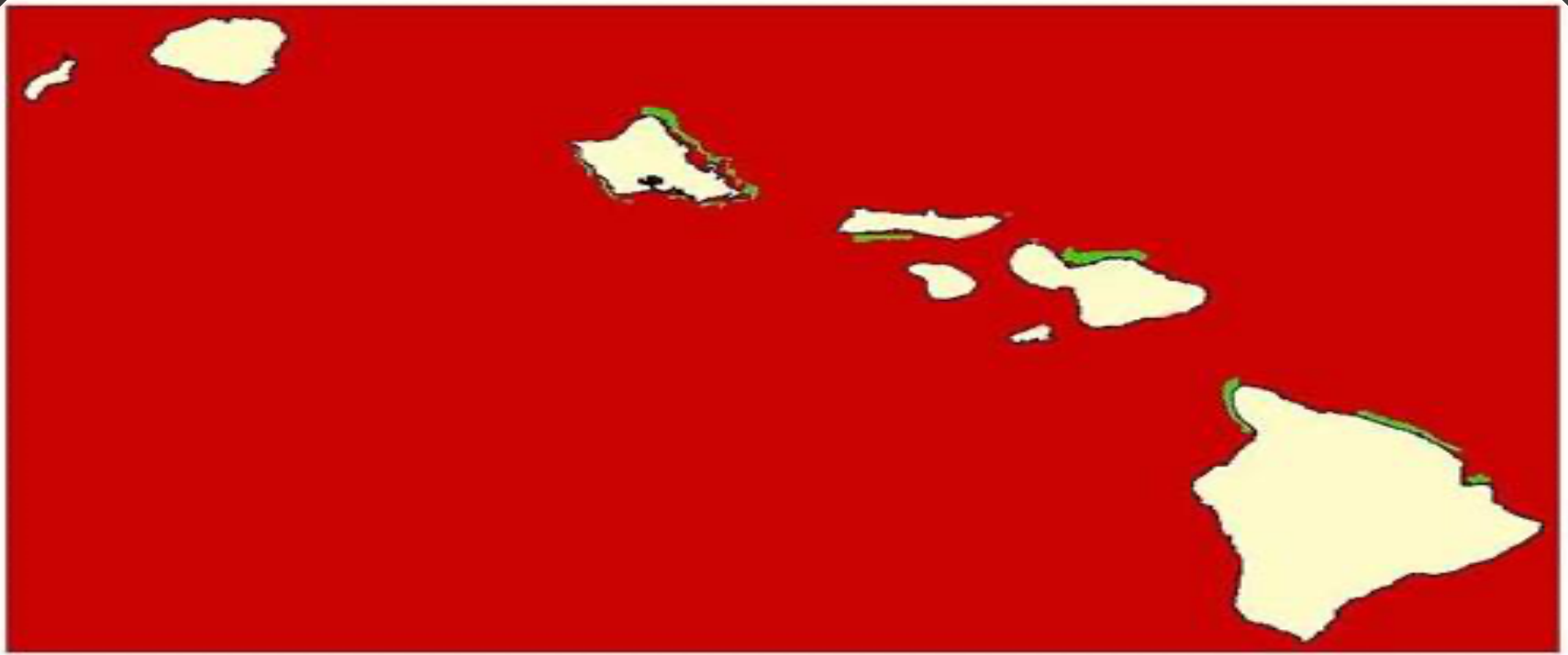
GIS in Hawaiian Aquaculture

- 2003, Young et al in Hawaiʻi
  - Examined: bathymetry, restricted, water classifications, 3-mile boundary
  - ID minimal conflicting sites
    - High
    - Marginal
    - No potential for aquaculture

GIS in Hawaiian Aquaculture

100   0   100   200   Miles

Potential Aquaculture Areas
- Restricted
- 1
- 2
- 3
- No Data

Selection VS Suitability

- Matter of scale
  - Selection:
    - ID specific spot where to place farm
    - Local
    - Well studied, data rich environments
  - Suitability
    - ID general areas that may be possible (planning, environmental management)
    - Regional
    - National level models (LENKA), rely on statutes and laws as well as science

Objectives

- Create a minimal data-set framework based on publically available data
  - Identifying suitable areas for further detailed research (adapted from FAO)
    - Most Suitable
    - Moderately Suitable
    - Least Suitable
- Transferable with low overhead cost
  - Home computer with moderate specs and ArcGIS software
  - Free /low-cost information

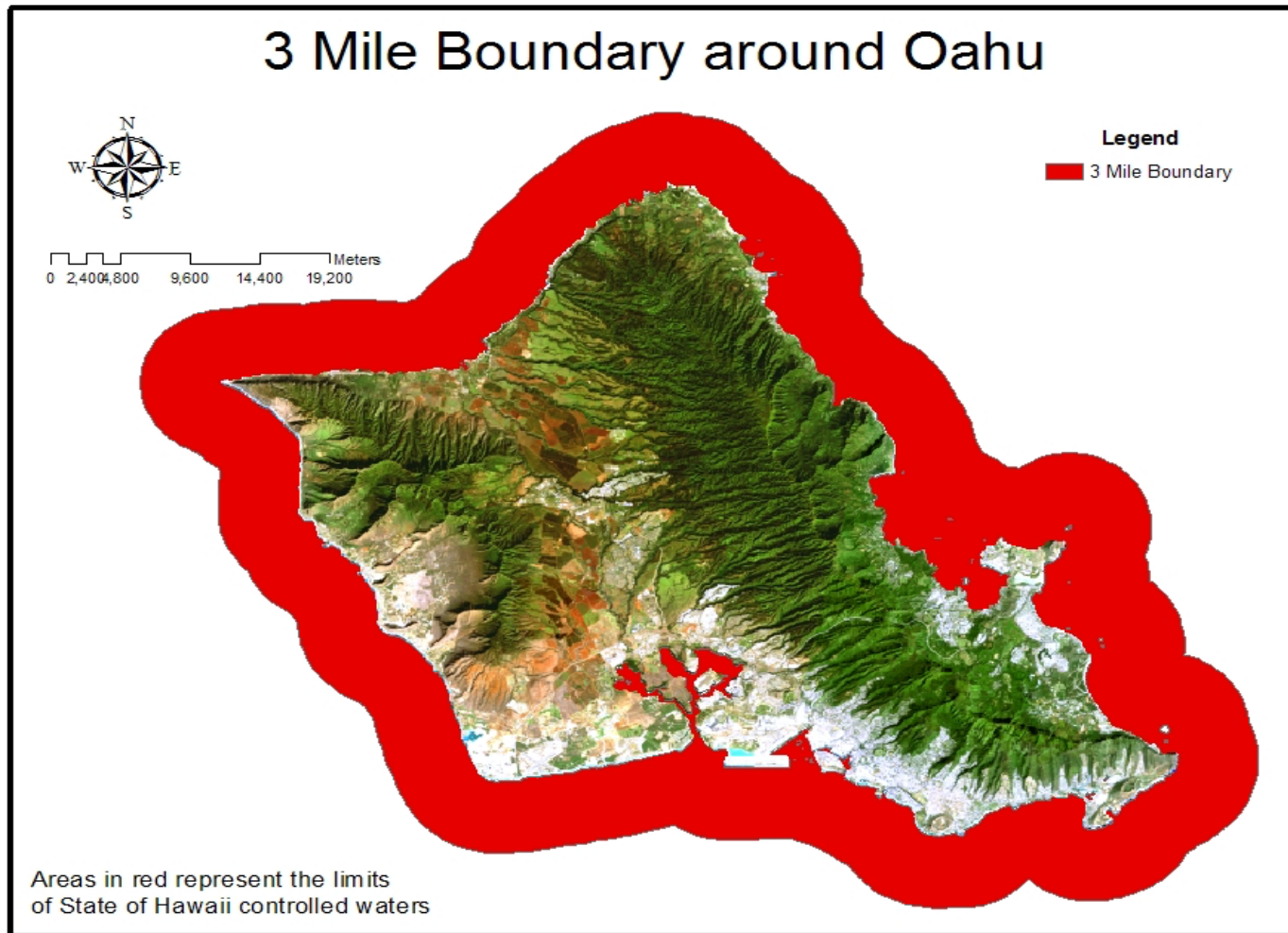# The Framework Components

Framework Components

- Basic & Military Constraints:
  - Areas incompatible with offshore cages
- 3 broad criteria
  - Environment
  - Economics
  - Social-scenarios
- WLC
  - Environment + Economic + Social

Limitations

3 Mile Boundary around Oahu

Legend
3 Mile Boundary

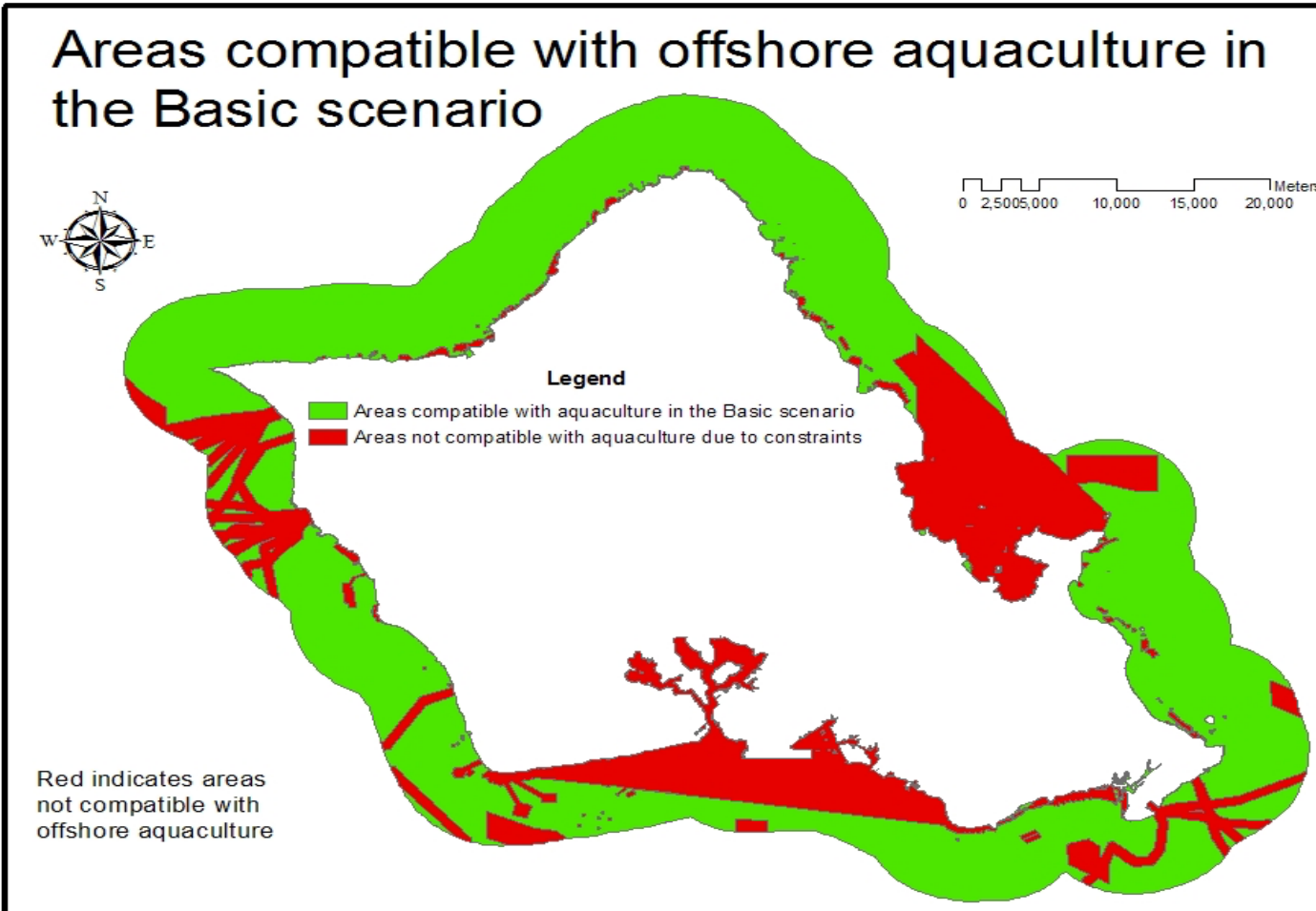Areas in red represent the limits of State of Hawaii controlled waters

Basic Map Contents

- Anything that can conflict (the kitchen sink approach)
  - If point data, created buffer
  - Buffers based on published data (some layers no buffer)
    - Wrecks assumed average was 30m
- Has to be detailed as possible
  - Offshore farms have exclusive use zones

Basic

Areas compatible with offshore aquaculture in the Basic scenario

Legend
- Areas compatible with aquaculture in the Basic scenario
- Areas not compatible with aquaculture due to constraints

Red indicates areas not compatible with offshore aquaculture

Military

Areas compatible with offshore aquaculture in the Military scenario

Legend
- Areas compatible with aquaculture in the Military scenario
- Areas not compatible with aquaculture due to constraints

Red indicates areas not compatible with offshore aquaculture
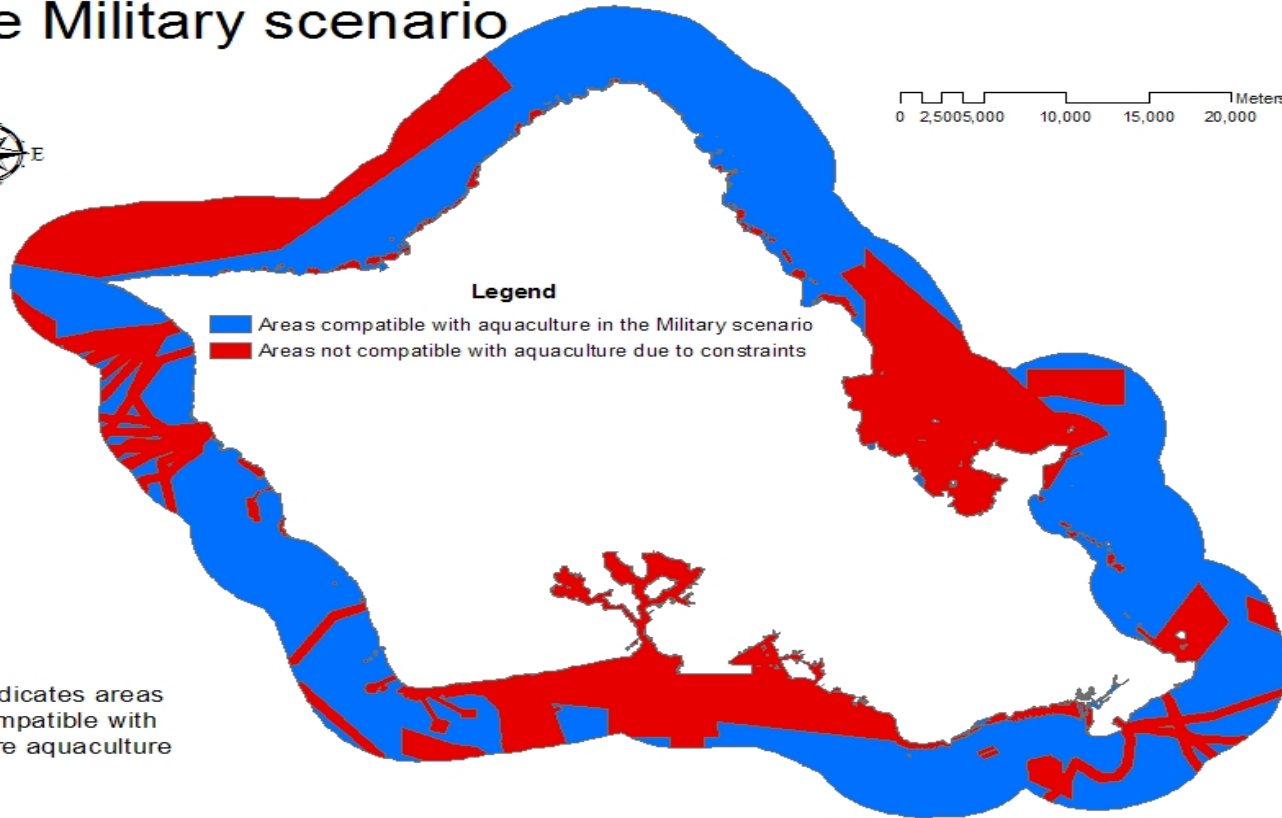
Area

Layer	Size (m^2)	%
Oʻahu Full Extent	1,310,550,784	100
Basic	924,000,191	70.5
Military	769,486,606	58.7

Environmental

Environmental

- Based on publications and existing site suitability models
 - Basic and near-ubiquitous trait: Bathymetry
    - Missing data interpolate using Natural Neighbor
- 3 classifications
  - 25m-50m
  - 51m-75m
  - 76m-100m

Bathymetry

Depth Ranges around Oahu between 25m-100m

Legend
- 25m-50m
- 51m-75m
- 76m-100m
- Areas not compatible with aquaculture due to depth

Red indicates areas not compatible with offshore aquaculture
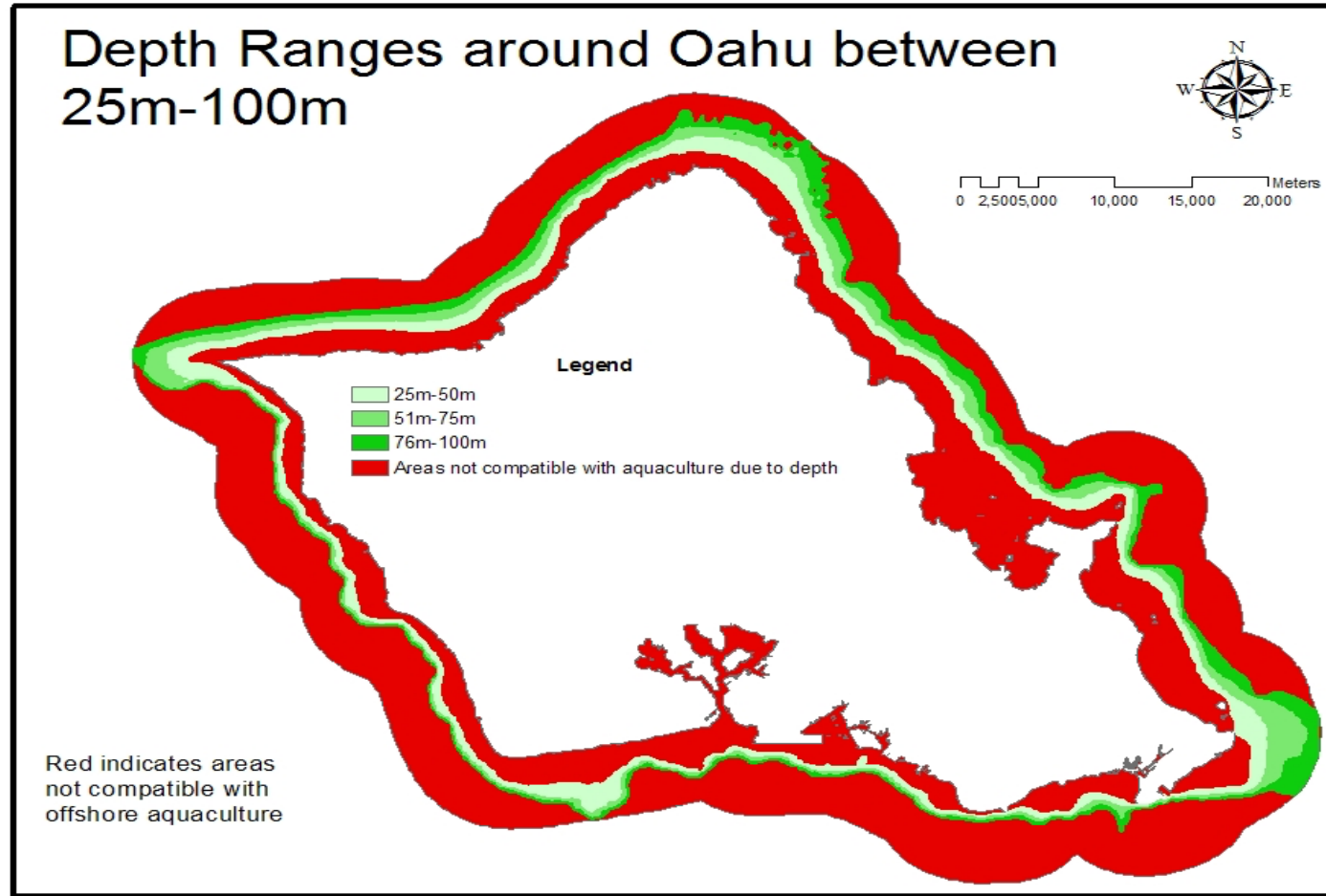
Bathymetry Military

Military scenario depth ranges around Oahu between 25m-100m

Legend
- 25m-50m
- 51m-75m
- 76m-100m
- Areas not compatible with aquaculture due to constraints

Red indicates areas not compatible with offshore aquaculture
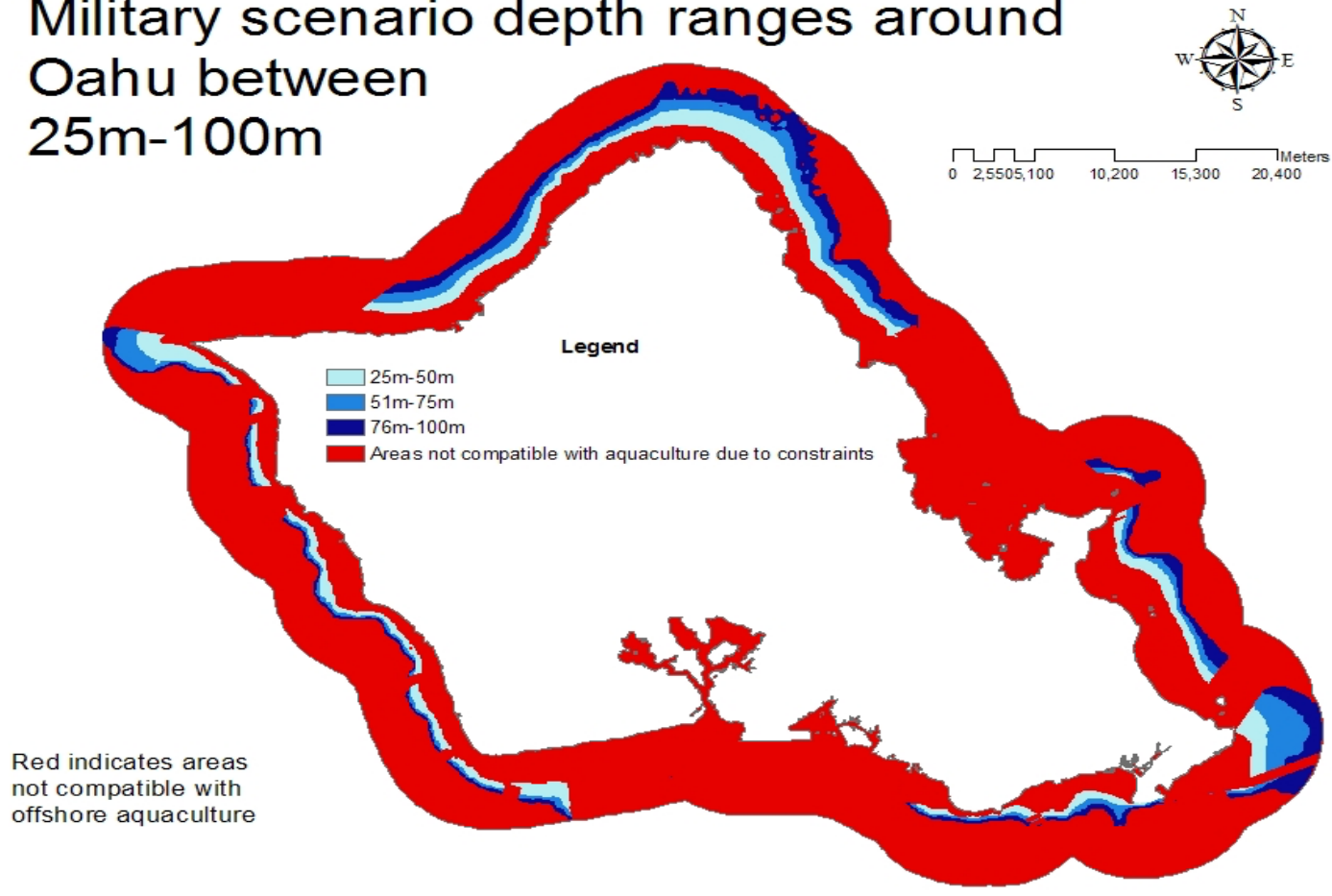
Environmental

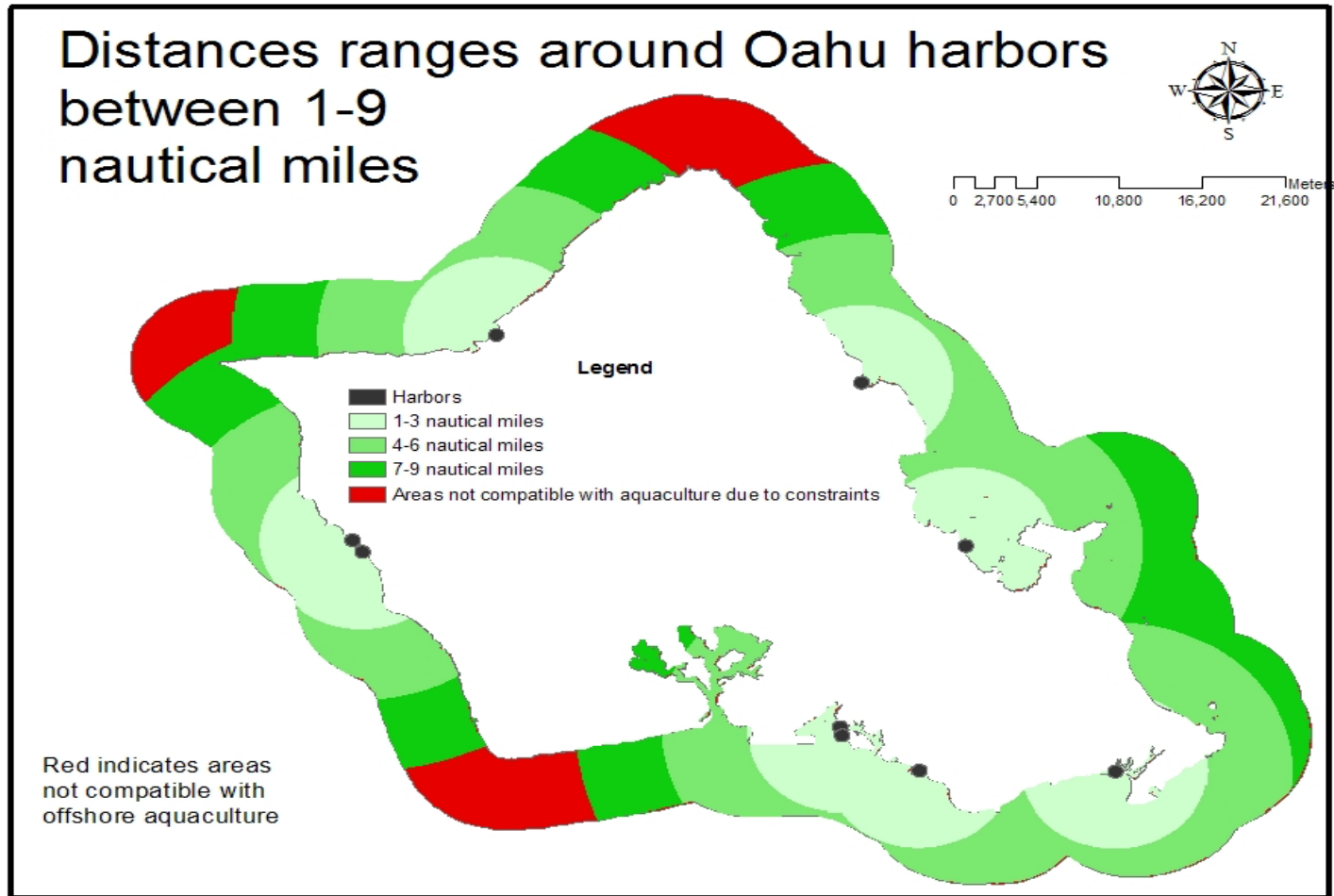| Depth	Full Extent Size (ha)	Base Size (ha)	Military Size (ha)
25m-50m	1,196,870	9,895	8,151
51m-75m	950,858	7,692	6,431
76m-100m	925,996	8,253	6,900
Total	3,073,724	25,840	21,482

Economics

Economics
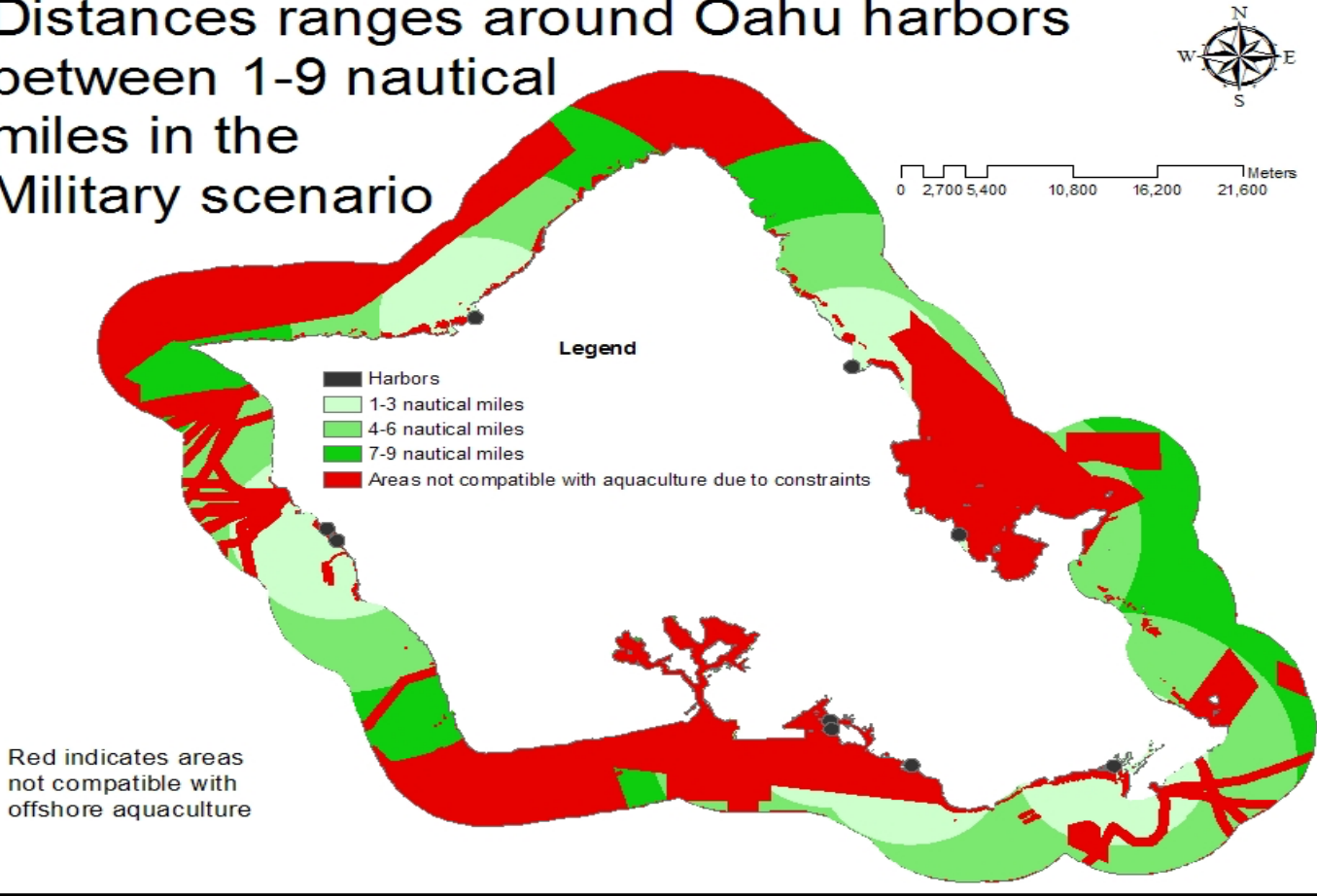
- Any harbor with reasonable area around it can be used
  - Storage space for feed maintenance equipment
- Why only distance from harbor?
- 3 classifications
  - 9 knots typical ship
  - 1-3 nautical miles
  - 4-6 nautical miles
  - 7-9 nautical miles

Economics

Distances ranges around Oahu harbors between 1-9 nautical miles

Legend
- Harbors
- 1-3 nautical miles
- 4-6 nautical miles
- 7-9 nautical miles
- Areas not compatible with aquaculture due to constraints

Red indicates areas not compatible with offshore aquaculture

Economics Military

Distances ranges around Oahu harbors between 1-9 nautical miles in the Military scenario

Legend
- Harbors
- 1-3 nautical miles
- 4-6 nautical miles
- 7-9 nautical miles
- Areas not compatible with aquaculture due to constraints

Red indicates areas not compatible with offshore aquaculture

Economic

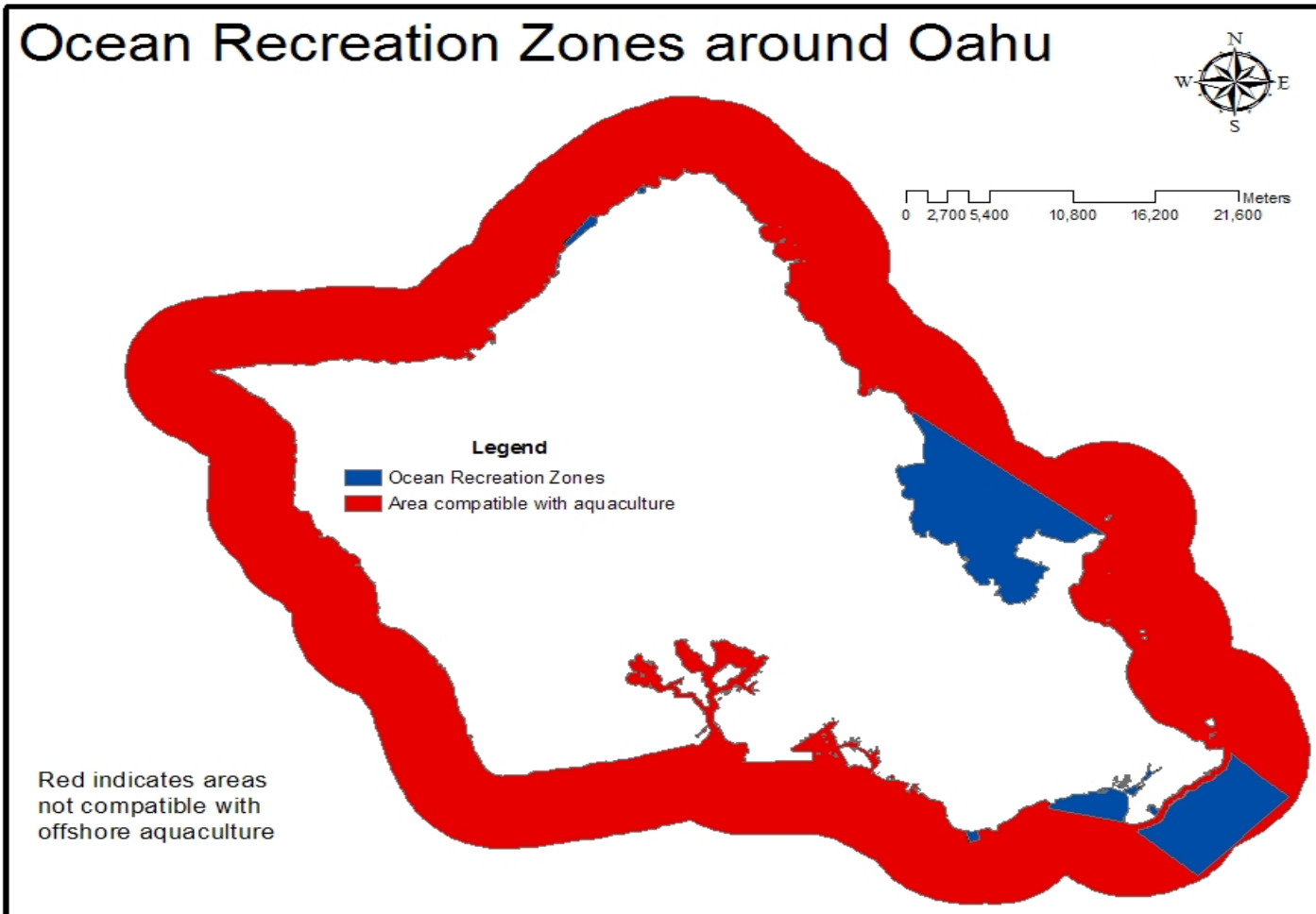| Distance (nautical miles)	Full Extent Size (ha)	Basic Size (ha)	Military Size (ha)
1-3	33,008	17,361	16,995
4-6	51,878	36,186	29,078
7-9	30,441	25,490	20,284
Total	115,327	79,037	66,357

Social

Ocean Recreation
&
 Konohiki

Social

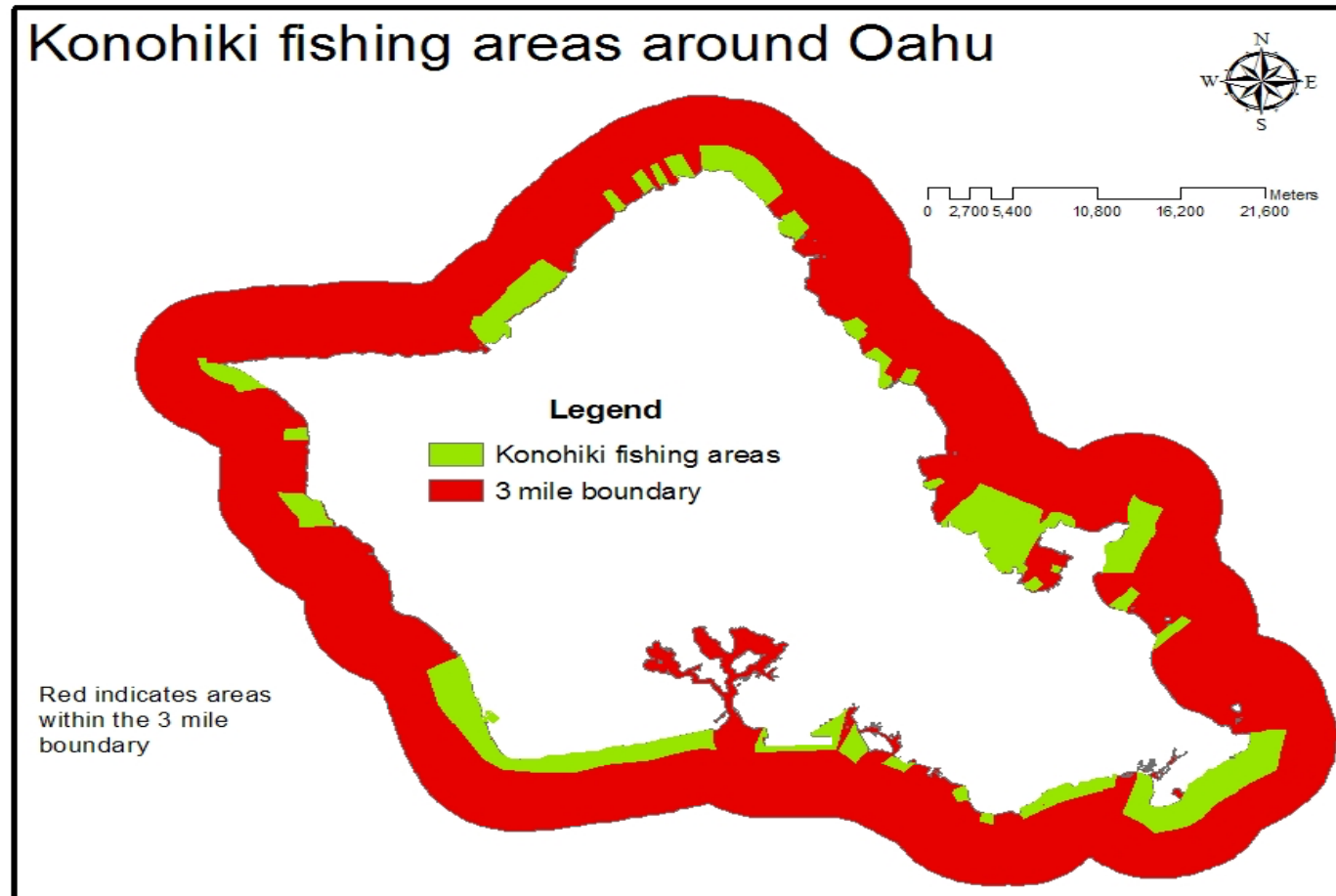- Modern use
  - Ocean Recreation Zone
    - Based on DLNR regulations
- Traditional use
  - Konohiki fishing area associated with Ahupuaʻa
    - Historically important
    - Proxy for cultural uses

Ocean Recreation

Konohiki

Konohiki fishing areas around Oahu

Legend
- Konohiki fishing areas
- 3 mile boundary

Red indicates areas within the 3 mile boundary

COMBINED

WLC Military

WLC predicted areas suitable for aquaculture around Oahu in the Military scenario

Legend
- Cates Farm
- Most Suitable
- Moderately Suitable
- Least Suitable
- Areas incompatible with aquaculture due to constraints

Red indicates areas incompatible with aquaculture
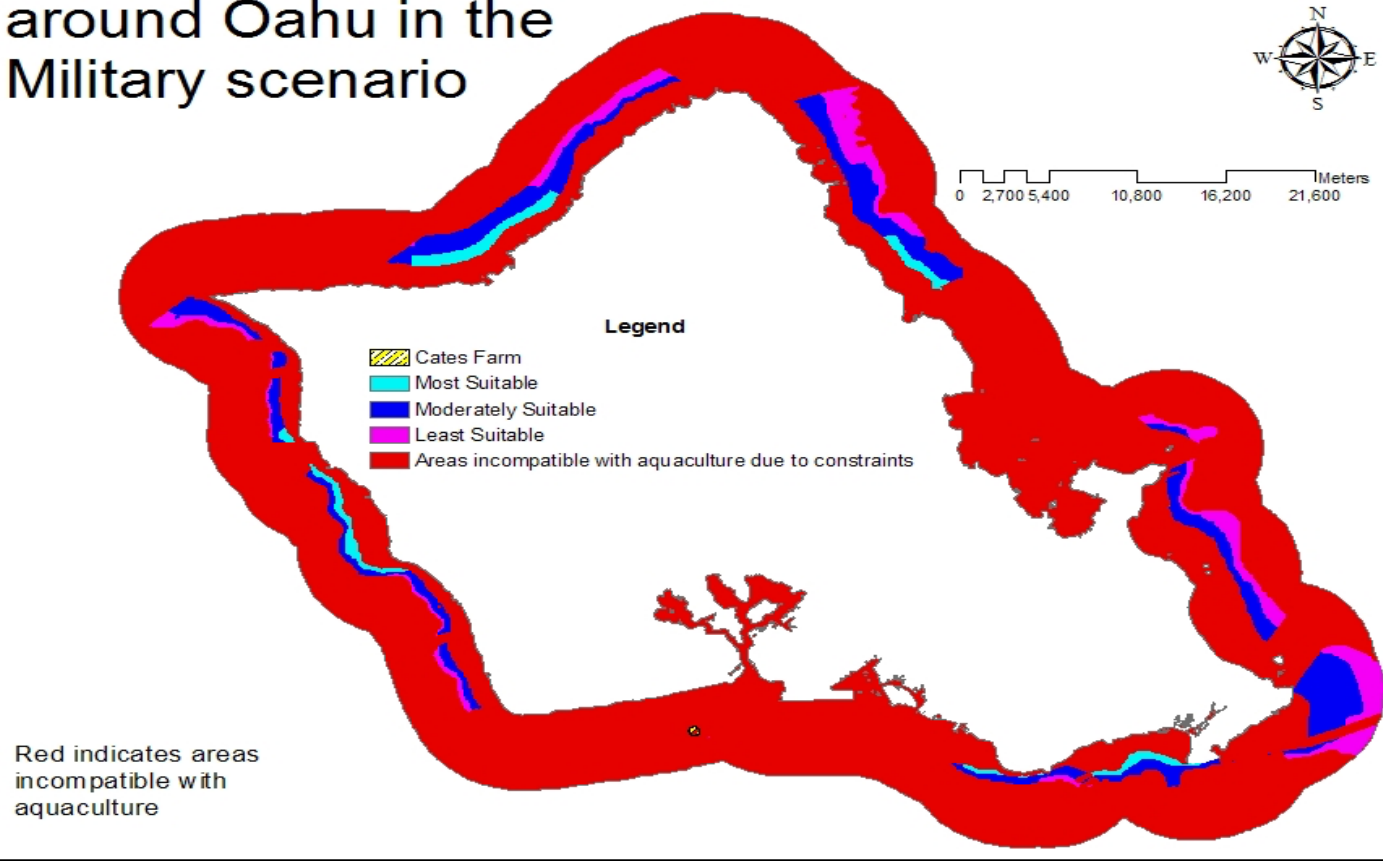
WLC Sizes

WLC Prediction	Full Extent Size (ha)	Basic Size (ha)	Military Size (ha)
Most Suitable	3,304	2,020	2,020
Moderately Suitable	15,430	11,547	9,532
Least Suitable	8,159	6,643	5,231
Total	26,893	20,210	16,783

Discussions
&
Conclusions

Validation

Model validation via overlap of Cates far with benthic layer and distance from harbor in the Military scenario

Legend
- Cates Farm
- 25m-50m
- 51m-75m
- 76m-100m
- Harbors
- 1-3 nautical miles
- 4-6 nautical miles
- 7-9 nautical miles
- Areas incompatible with aquaculture due to constraints

Red indicates areas incompatible with aquaculture
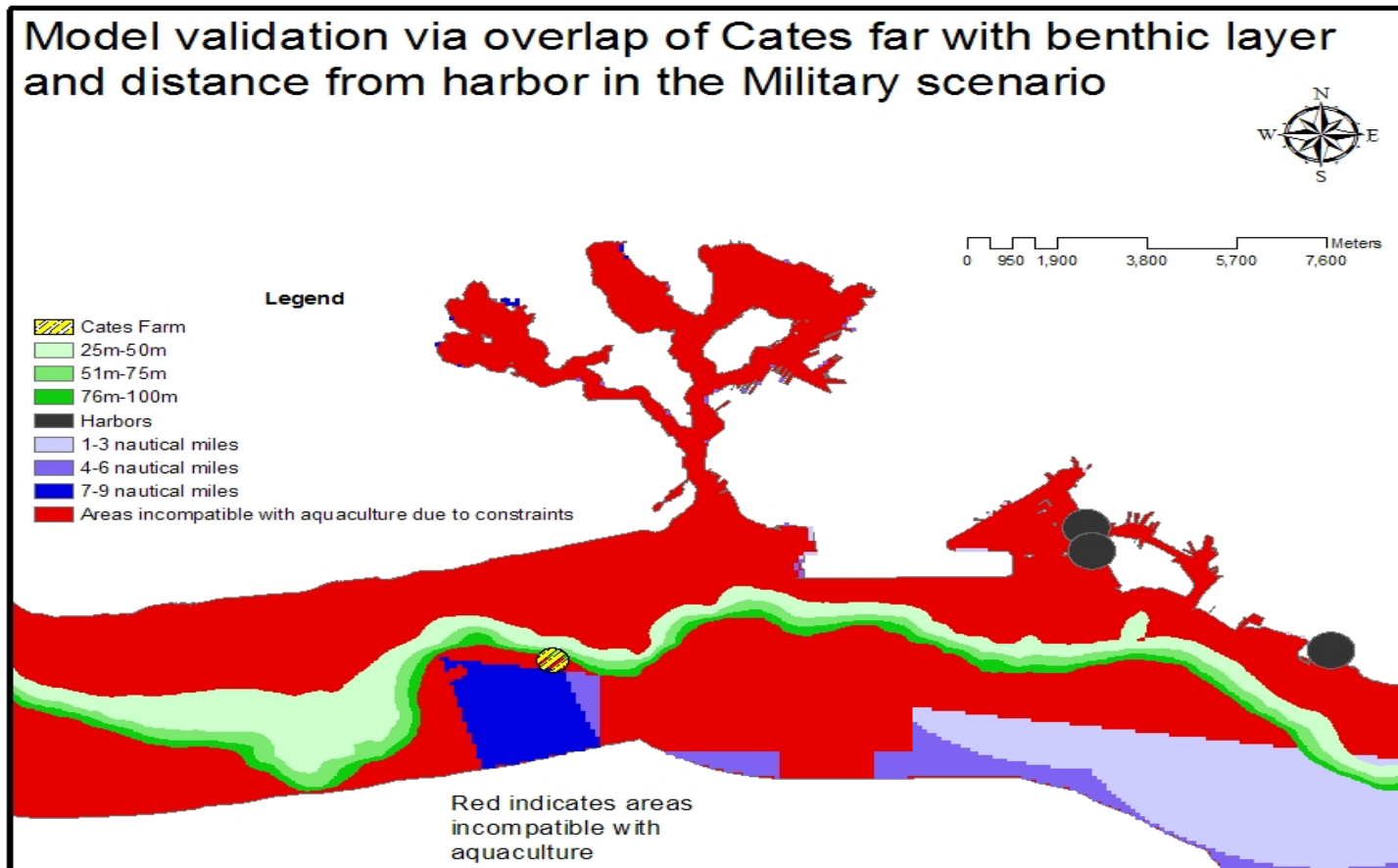
Discussion

- Results comparison to ADP Phase 1
  - Problematic at best
  - Low resolution state-wide map, no details or quantifiable numbers (Phase 2 never completed)
- Results comparison to other regional scaled models
  - Incorporates similar information
    - New to the Pacific Islands

Discussion

- Errors
  - Rasterization
  - Public data
    - Poor metadata
    - Improper digitization
    - Interpolation
  - Error not uncommon in GIS analysis

Conclusions

- ◉ Importance of suitability
- ◉ Proper siting
  - ● Saves:
    - ○ Time
    - ○ $ (governments, and businesses)
  - ● Eases growing pains in new markets
    - ○ Local community support
- ◉ Few places around Oʻahu possible for expansion
  - ● State focus on Maui which is equally problematic
- ◉ Structure of model functions:
  - ● Cates operation within acceptable area

Conclusions

- Needed for next phase (Site Selection)
  - AHP based WLC with more detailed information
    - Information allows for alteration of weights
  - More accurate bathymetry
  - Currents
  - Waves
  - Temperature
  - Turbidity
  - Tides
  - More detailed infrastructure

Questions?