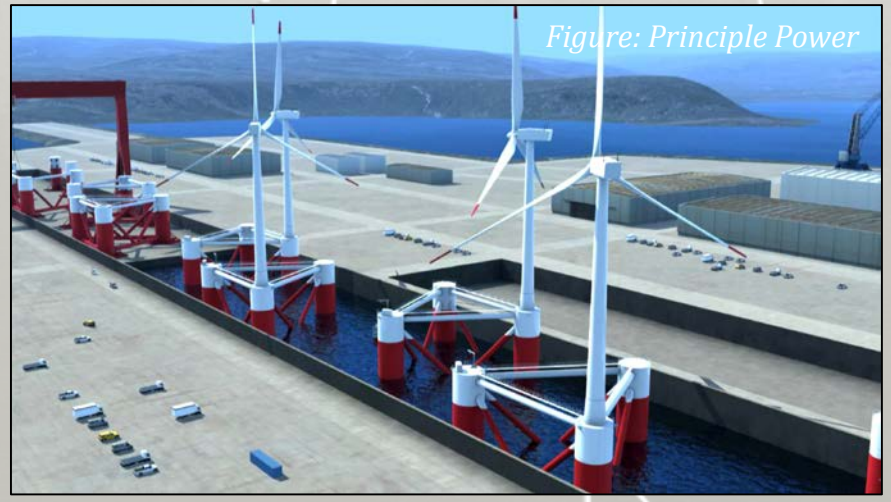
# Infrastructure to Support Offshore Floating Wind

## *Focus on California*




**Aaron Porter, P.E., & Shane Phillips, P.E.,**
**Mott MacDonald**
**Seattle, WA**

OCS Study
BOEM 2016-011

**BOEM Project Manager:**
**Mark Eckenrode**

# Objectives

- Estimate navigation, vessel, and port infrastructure requirements to support Offshore Floating Wind (OFW) development
- Focus on US Pacific West Coast and Hawaii
  - Today: California focus
- Assess existing and potential future capability to support large-scale and demonstration-scale OFW


*Note: Not focused on traditional foundation offshore wind (e.g. Block Island)*

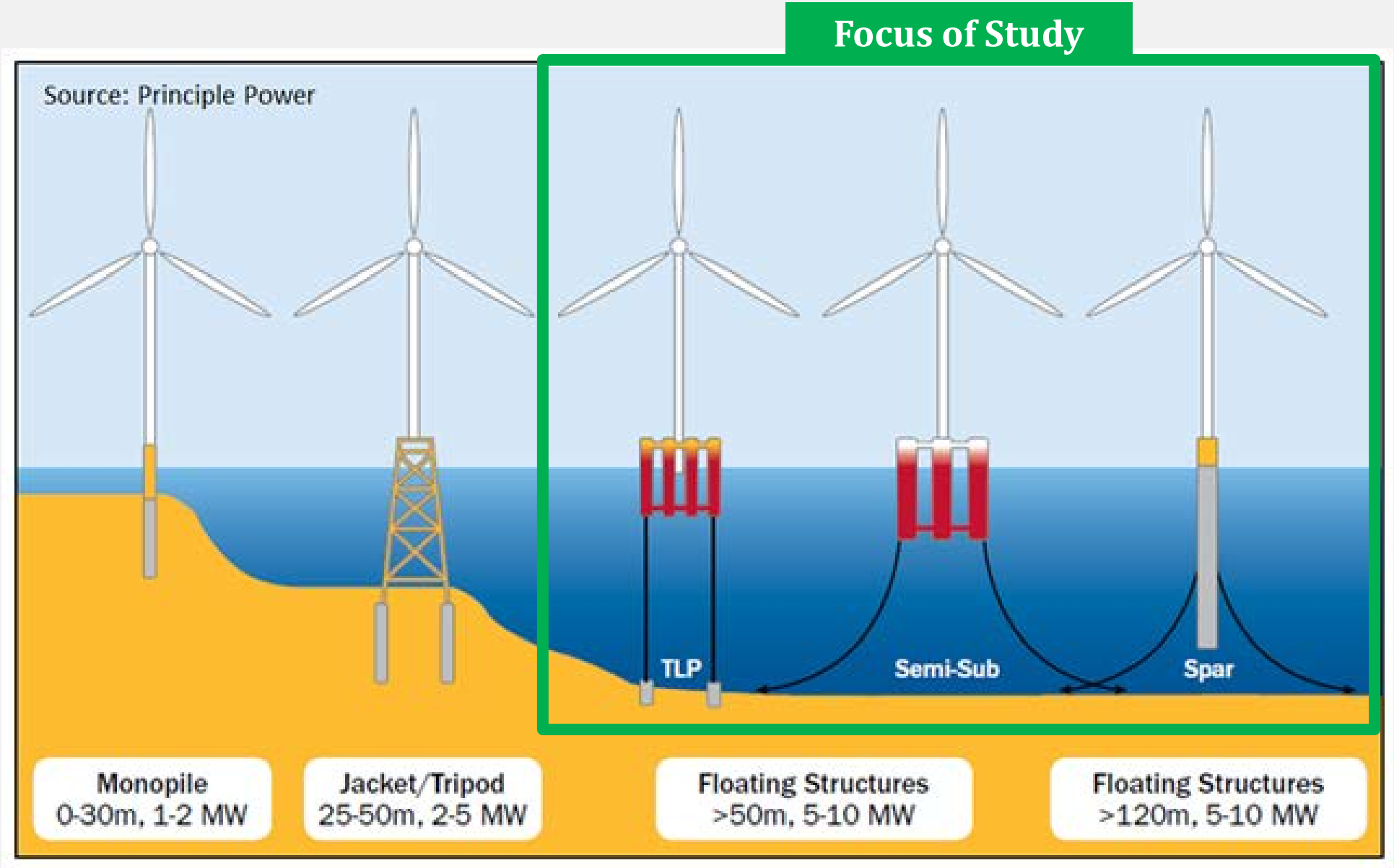
# Why?

BOEM Bureau of Ocean Energy Management | 2016-011

- "All ports on the Pacific Coast shall be studied that have available or planned infrastructure to support the offshore renewable industry"
- Environmental reviews and evaluations
- Inform policy decisions

***Few examples of floating wind → No commercial prototypes***

# Basis of Analysis - Devices

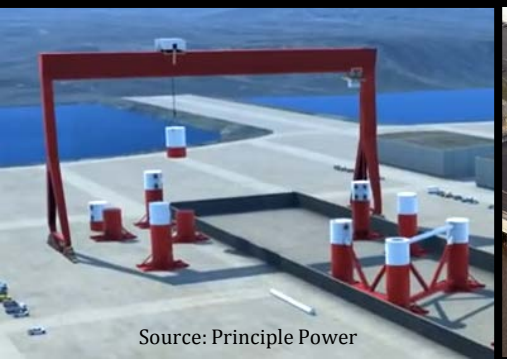
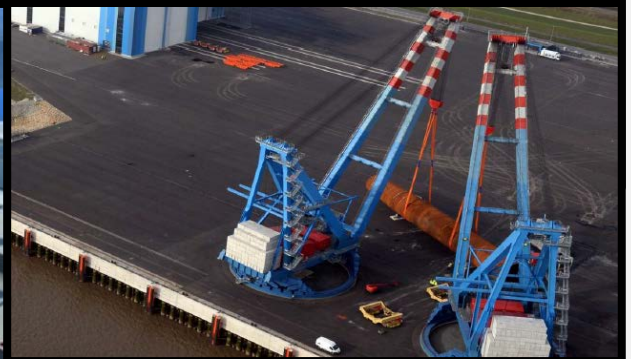


# Methods

- Data Collection:
  - Marine Contractors, Ports, Developers
  - Key → Literature Review.
- Port role Classification
  - Assembly/Installation, Fabrication, Quick Response, Cluster
- Conceptual-Level Engineering Analysis
- Vessel Requirements and Operational Limitations
- Prototype Analysis
  - Europe, Demonstration-Scale Floating, Oil and Gas
- Case Studies
- Assessment of Regional Port Characteristics






Source: Siemens

Source: Principle Power


# Considerations

MOTT MACDONALD

## Transport

- Nav. Channel Width
- Nav. Channel Depth
- Height Restrictions
- Device Type
- Metocean Conditions
- Vessel Availability
- Component Size
- Safe Harbor

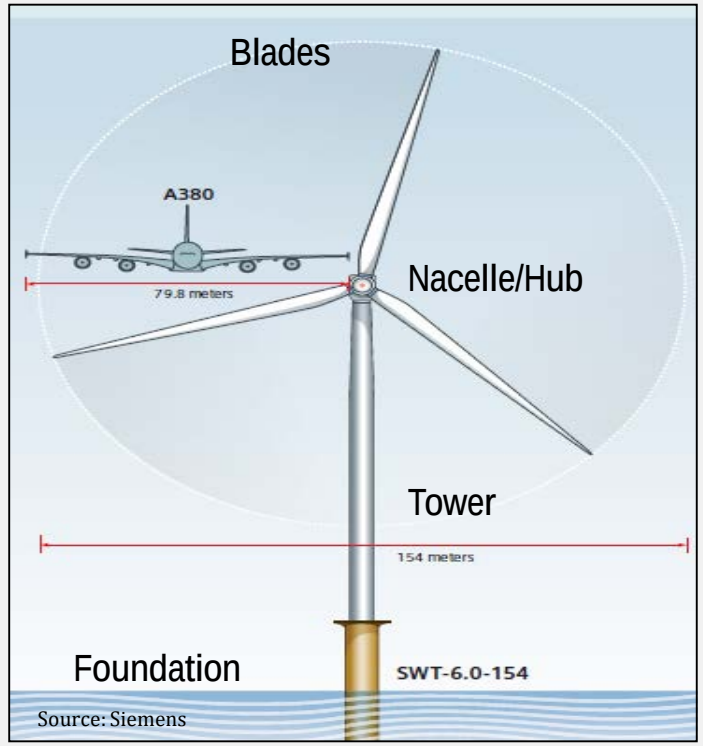
## Infrastructure

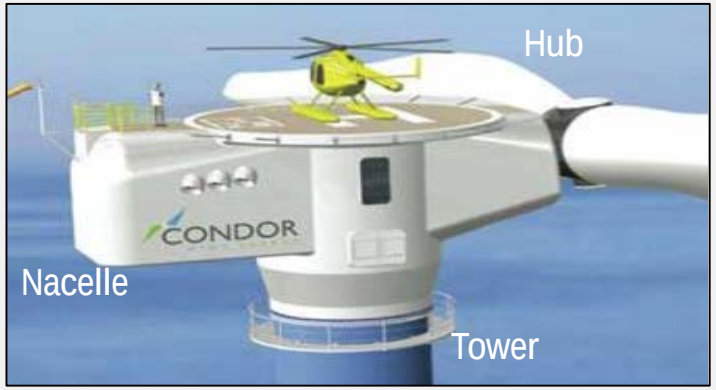
- Skilled Labor Force
- Quayside Space
- Road/Rail Connection
- Component Size
- Device Type
- Crane Capacity
- Quayside Bearing Capacity
- Dry-dock/Shipyard
- Vessel Availability
- Vessel Berths

# Offshore Wind Turbine Size

MOTT MACDONALD

| Component | Land-based 1.5-2MW* | Offshore 6-8MW | Transport |
|---|---|---|---|
| **Tower** | | | |
| **Height** | ~180ft.-220 ft. | 250ft. -450ft. | May be transported in pieces. |
| **Weight** | ~150-230 tons | ~400 tons | |
| **Nacelle & Hub** | | | |
| **Length** | ~35 ft. | ~50ft. | May be transported in pieces. |
| **Weight** | ~75 tons | ~300-400 tons | |
| **Blades** | | | |
| **Length** | ~ 130 ft. | ~250ft. | Single piece only |
| **Weight** | <10 tons | 25-35 tons each | |




* E.g., Wild Horse Windfarm, WA

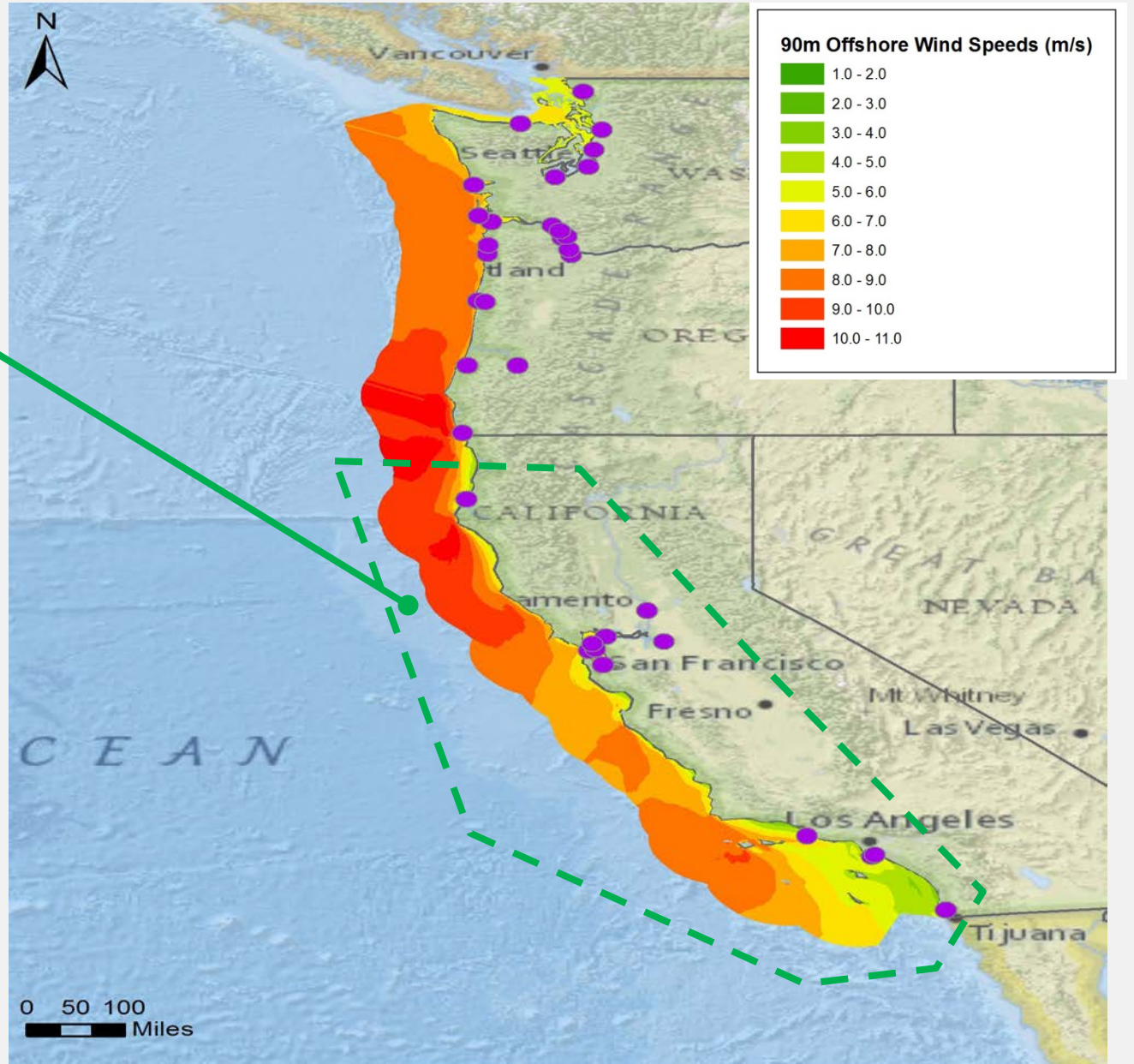
# PORT LOCATIONS

## CA - Large Ports

### Northern
- Humboldt Bay

### Central
- SF Bay ~ 7 Deep Draft

### Southern
- Hueneme
- LA/Long Beach
- San Diego



# Port Classification Functions


Fabrication & Construction Port (FCP)


Quick Reaction Port (QRP)

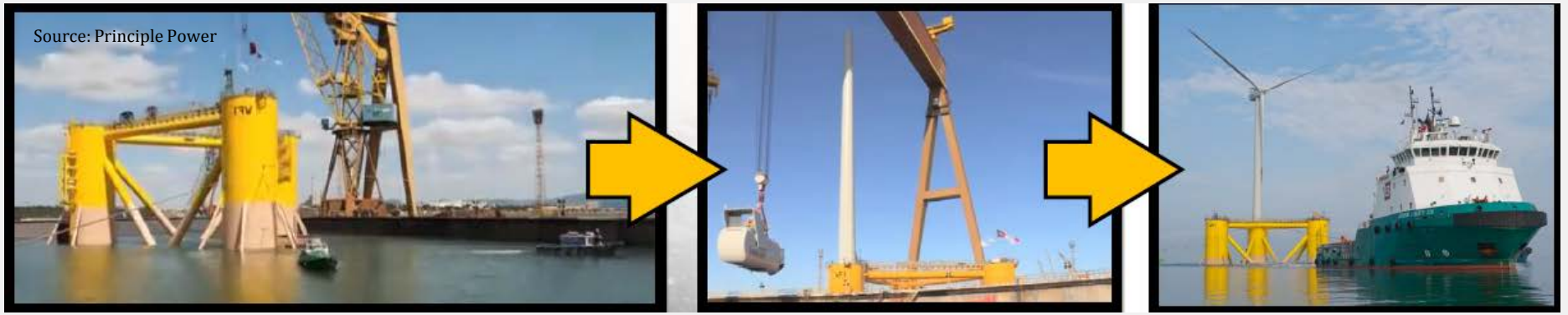

Assembly Port (AP)

- QRP
  - Crew Transfer, O&M, Pre-installation
- FCP
  - Construction staging, pre assembly, transport of hub and devices, fabrication of nacelle, blades, etc..
- AP
  - Final assembly, marine tow to final location, large staging/storage
- Combinations

# Prototype – Assembly & Installation

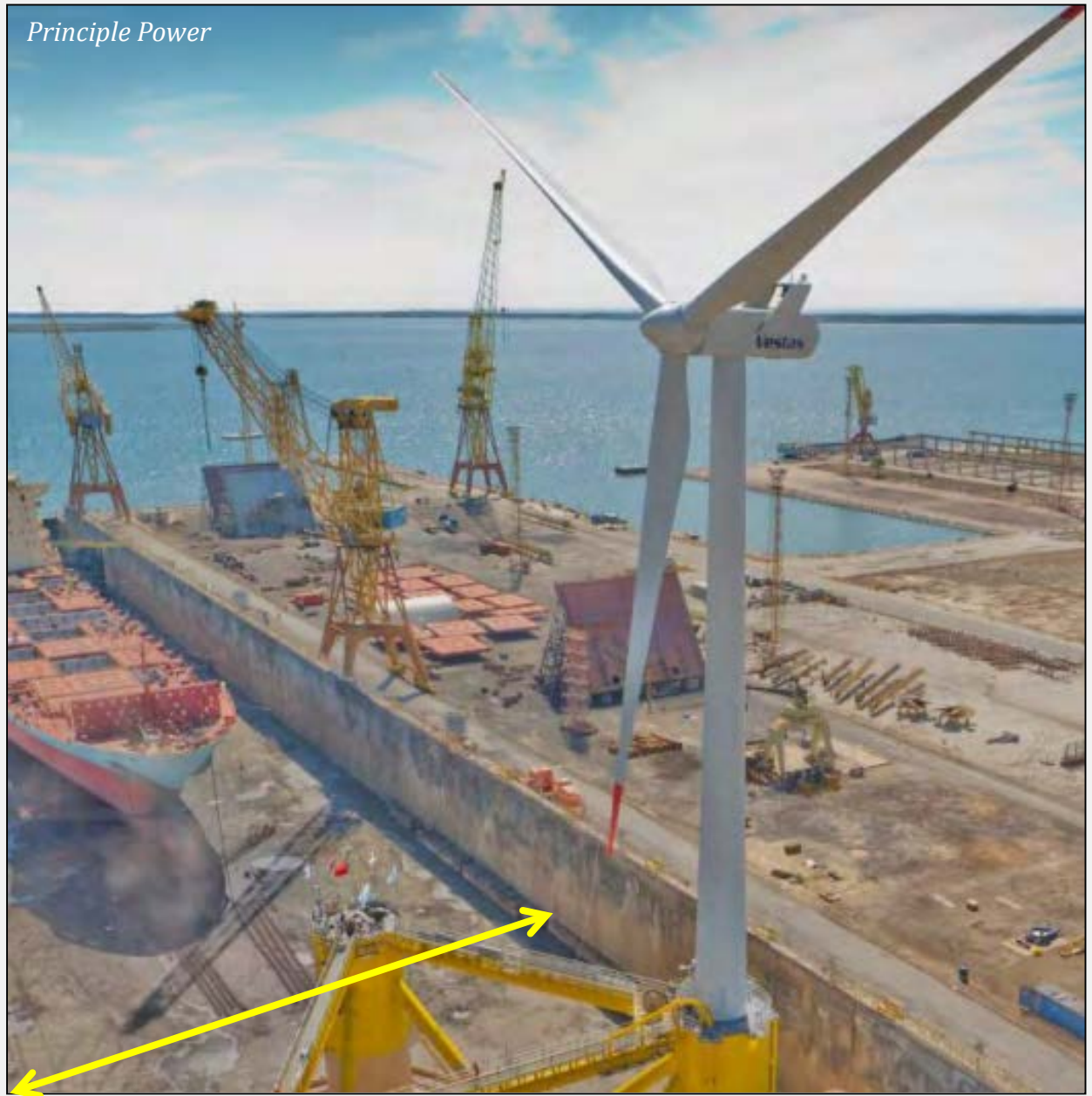
MOTT MACDONALD

Assembled upright at Port. E.g., Semi-Submersible




Towed to sea for assembly. E.g., Spar


# Prototype Port - Assembly




## Lisnave Shipyard

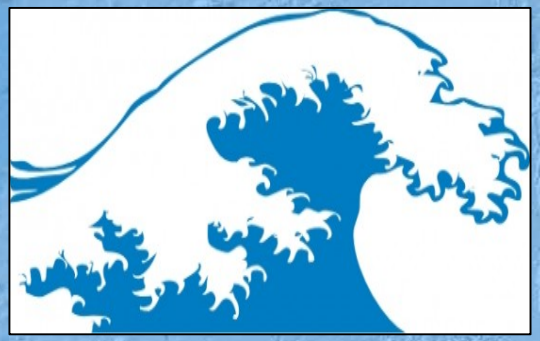
Wide Dry-dock: 250 ft. (76m)
Heavy-lift Crane: 500 tons
Support Cranes: 100 tons
**Air-draft Restriction: None**
Draft: 25ft. (7.6m)

# Ports – Air draft Restrictions

Limits Assembly Location and Installation Method

# Metocean Conditions – Open Ocean

*PACIFIC OCEAN*



| WA, OR, CA, HI Average, Typ. | Winter | Summer |
|---|---|---|
| Hs (ft. ) | 9-10ft. | 6-7ft. |
| Tp (sec) | 11-12 sec | 9-10 sec |

| Block Island[1], (Atlantic) Typ. | Winter | Summer |
|---|---|---|
| Hs (ft. ) | 5-6ft. | ~3ft. |
| Tp (sec) | 7-8 sec | 7-8sec |

Harsh Environment:

- At-sea construction
- Assembly location
- Installation method
- Long waves

1. NOAA Buoy 40097

# Case Study – Conceptual Example









**GREEN – POTENTIALLY FEASIBLE** **YELLOW – FURTHER INVESTIGATION** **ORANGE– NOT LIKELY FEASIBLE**

# Key Findings – Prototype


- **Utilize Existing Equipment, Vessels, Infrastructure**
  - **Minimize capital expense**
- **Combination of locations**
  - **Broad geographic reach (Within and beyond CA)**
- **Large tow distances possible**
  - **Common in energy sector**
  - **Block Island prototype**

# Key Findings – Commercial Production


- 3 Port Classification Types
  - Fabrication
    - Medium to large Ports
    - Good transportation connections
    - Inland or coastal
  - Assembly
    - Most Restricted
    - Navigation Requirements (Channel & Air Draft)
  - Quick Reaction
    - Coastal Ports
    - Proximity to installation
    - Min 12’ depth channel

- Incentive for Infrastructure investments

# Key Findings - Infrastructure

**Commercial Scale Infrastructure**

- **Limited wide (200') dry dock facilities and marine railways**
- **Wind-specific assembly facilities don't exist**

**Navigation**

- **Air Draft restricts final assembly location**
- **Limited choices of ports with large quayside & deep draft channel**

**Ocean Navigation**

- **Tow Distance less critical than infrastructure; demonstration**
- **Safe Harbor Distance**

# Key Findings - Infrastructure

**Ocean Conditions**

- Wave height, length
- Operability Limitations
- Downtime
- Specialty Equipment


**Transportation**

- Overland connections for smaller component
- Large components fabricated at Port

**Port Infrastructure**

- Few Large Heavy Lift Cranes (>500 ton)
- High capacity wharf
- Quayside upland area
- Throughput

# FABRICATION PORTS: California

***Long-Term Commitment - May Require Purpose-Built Facilities***
***Quayside Space Limited - May Require Land (Re)development***

- Navigation
  - Good channel access & berth facilities
  - Air draft considerations
- Upland Infrastructure
  - Large upland space; limited availability
  - Good transportation & supply chain connectivity
  - High Capacity Wharf; limited availability
- Port Network
  - Good regional and inland network
  - Good access to supply chain
  - Marine Port Dependent
- Dry Dock Facilities
  - Currently Exist ~ Air draft restrictions; width optimized for vessels; marine rail system?
- Workforce
  - Large skilled workforce for fabrication

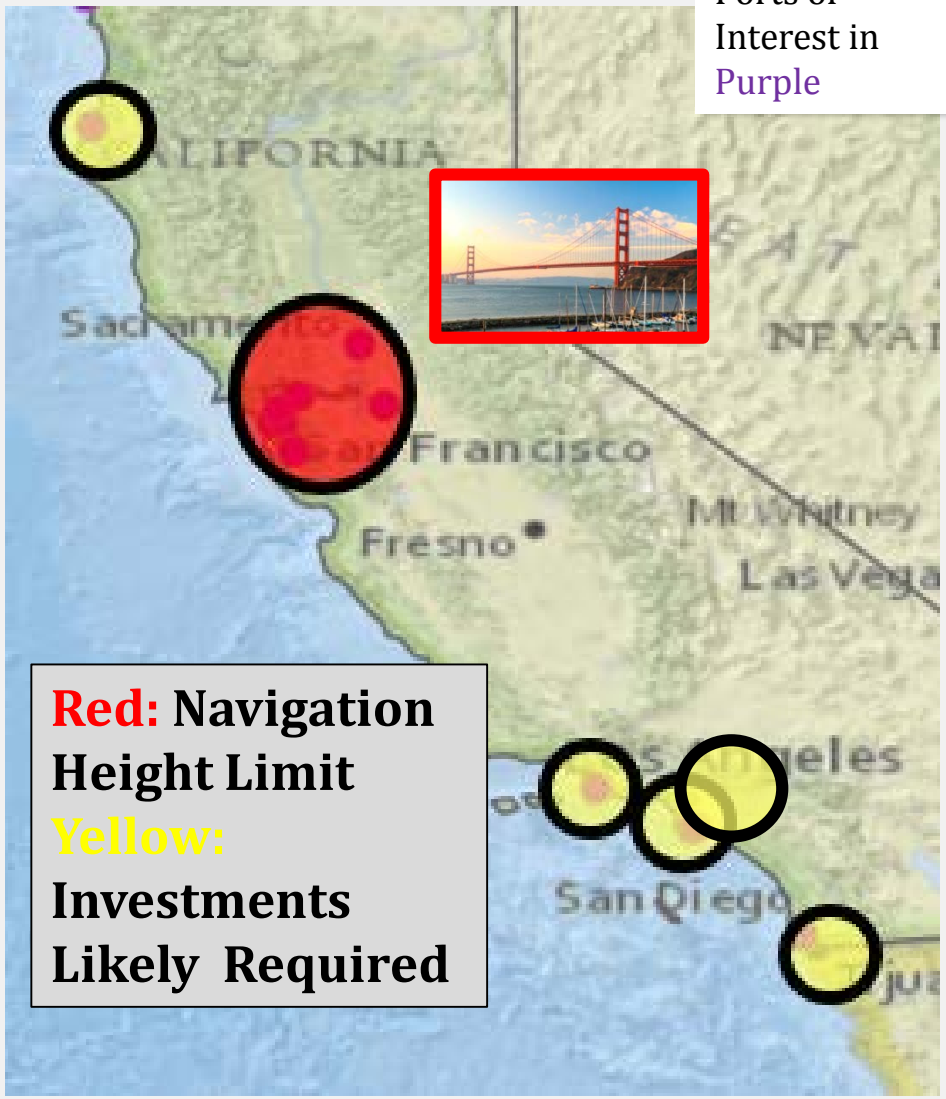
**Yellow: Investments Likely Required**

# ASSEMBLY PORTS: California

## *Port Facilities Require Upgrades*


- Navigation
  - Deep draft channels available
  - Air draft limit considerations
  - Assembly & Installation method dependent
- Met Ocean Conditions
  - N. Coast restrictions on vessel & assembly operations; downtime
  - Protected Harbor or alternative installation scheme
- Port
  - Largest West Coast Ports
  - Upland space exists; limited appropriate dedicated laydown areas
  - Good experience handling wind farm components
  - Single facility w/ attributes for large scale project not currently avail.

Ports of Interest in Purple



# Thank You


## Contact: shane.phillips@mottmac.com

### Detailed Report: www.boem.gov/BOEM-2016-011/

This study performed under BOEM Contract M15PD00019 (Prime: ICF International).
BOEM Contact: Mark Eckenrode.

**Aaron Porter, P.E. & Shane Phillips, P.E.**
**Mott MacDonald**
**425-977-2585**
**Seattle, WA**