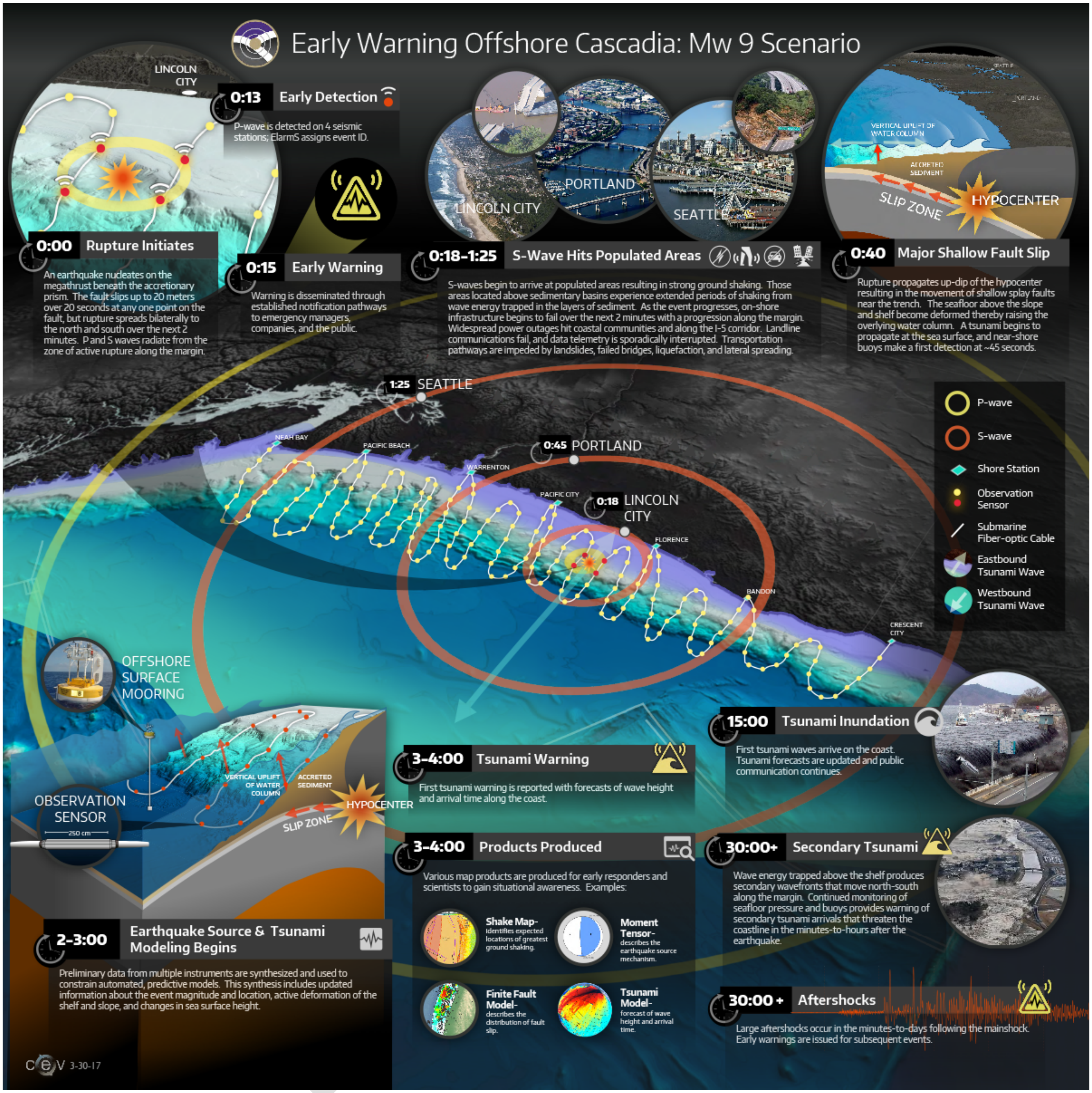
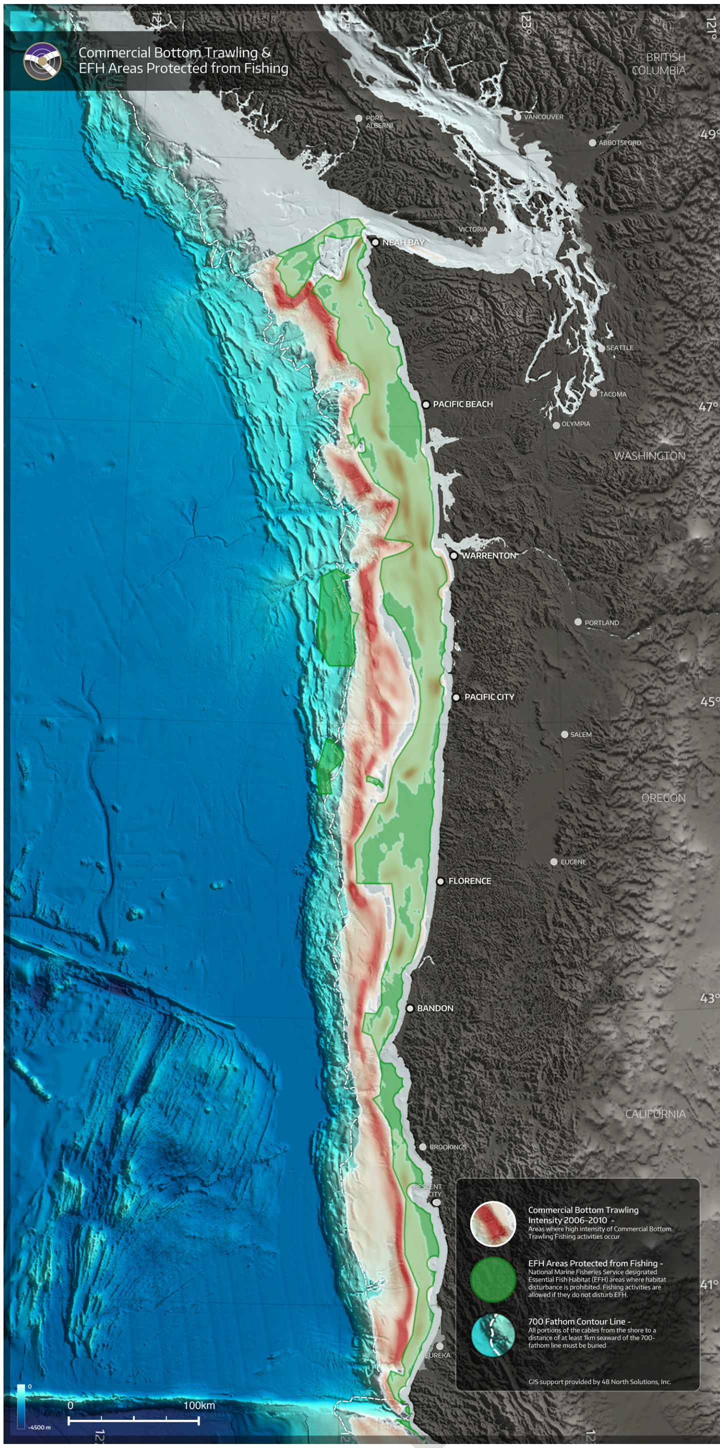
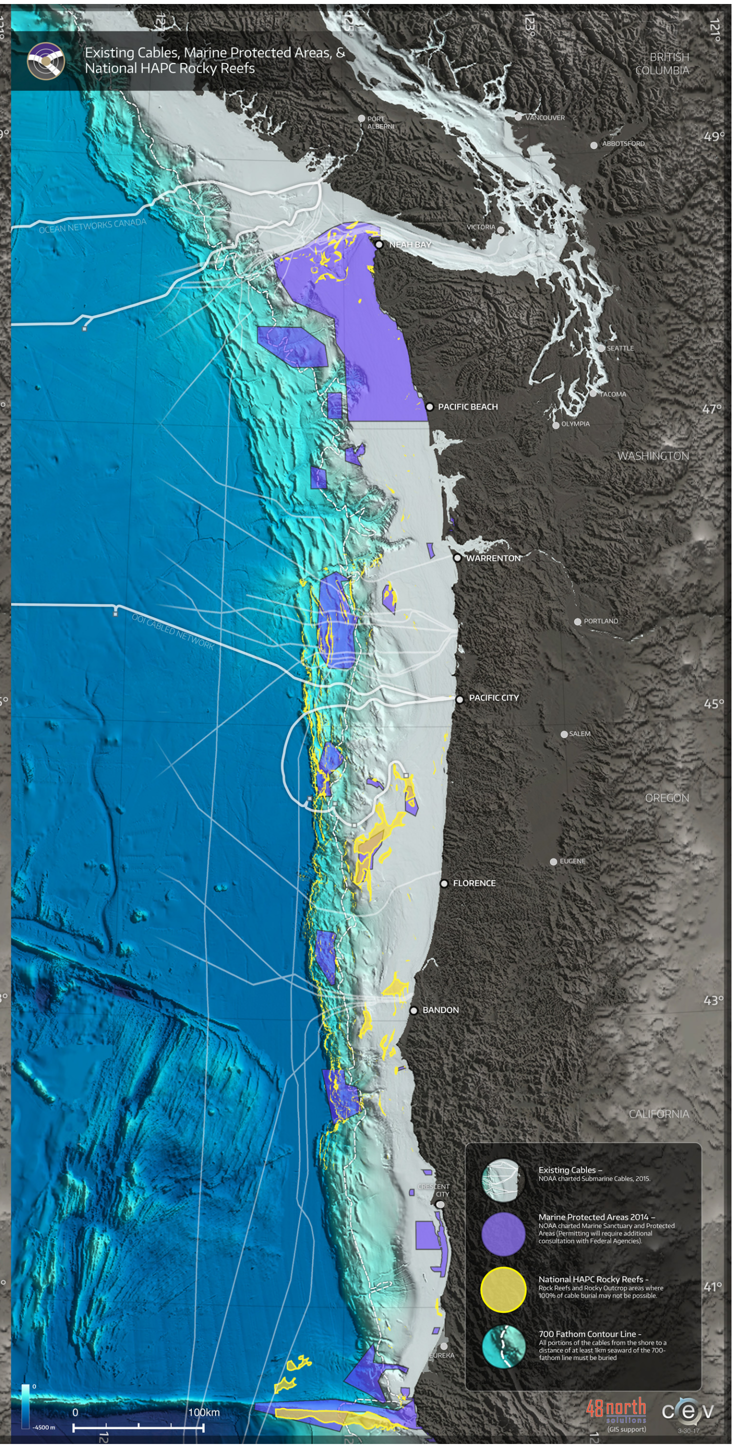
Appendix C

Workshop Graphics and Distributed Material

Full resolution versions of these graphics are included in the online version of the workshop report


Early Warning Offshore Cascadia: Mw 9 Scenario
LINCOLN CITY
0:13 Early Detection
P-wave is detected on 4 seismic stations; ElarmS assigns event ID.
0:00 Rupture Initiates
An earthquake nucleates on the megathrust beneath the accretionary prism. The fault slips up to 20 meters over 20 seconds at any one point on the fault, but rupture spreads bilaterally to the north and south over the next 2 minutes. P and S waves radiate from the zone of active rupture along the margin.
0:15 Early Warning
Warning is disseminated through established notification pathways to emergency managers, companies, and the public.
PORTLAND
LINCOLN CITY
SEATTLE
0:18-1:25 S-Wave Hits Populated Areas
S-waves begin to arrive at populated areas resulting in strong ground shaking. Those areas located above sedimentary basins experience extended periods of shaking from wave energy trapped in the layers of sediment. As the event progresses, on-shore infrastructure begins to fail over the next 2 minutes with a progression along the margin. Widespread power outages hit coastal communities and along the I-5 corridor. Landline communications fail, and data telemetry is sporadically interrupted. Transportation pathways are impeded by landslides, failed bridges, liquefaction, and lateral spreading.
VERTICAL UPLIFT OF WATER COLUMN
ACCRETED SEDIMENT
SLIP ZONE
HYPOCENTER
0:40 Major Shallow Fault Slip
Rupture propagates up-dip of the hypocenter resulting in the movement of shallow splay faults near the trench. The seafloor above the slope and shelf become deformed thereby raising the overlying water column. A tsunami begins to propagate at the sea surface, and near-shore buoys make a first detection at ~45 seconds.
1:25 SEATTLE
NEAH BAY
PACIFIC BEACH
0:45 PORTLAND
WARRENTON
PACIFIC CITY
0:18 LINCOLN CITY
FLORENCE
BANDON
CRESCENT CITY
P-wave
S-wave
Shore Station
Observation Sensor
Submarine Fiber-optic Cable
Eastbound Tsunami Wave
Westbound Tsunami Wave
OFFSHORE SURFACE MOORING
OBSERVATION SENSOR
250 cm
VERTICAL UPLIFT OF WATER COLUMN
ACCRETED SEDIMENT
HYPOCENTER
SLIP ZONE
15:00 Tsunami Inundation
First tsunami waves arrive on the coast. Tsunami forecasts are updated and public communication continues.
3-4:00 Tsunami Warning
First tsunami warning is reported with forecasts of wave height and arrival time along the coast.
3-4:00 Products Produced
Various map products are produced for early responders and scientists to gain situational awareness. Examples:
Shake Map- identifies expected locations of greatest ground shaking.
Moment Tensor- describes the earthquake source mechanism.
Finite Fault Model- describes the distribution of fault slip.
Tsunami Model- forecast of wave height and arrival time.
30:00+ Secondary Tsunami
Wave energy trapped above the shelf produces secondary wavefronts that move north-south along the margin. Continued monitoring of seafloor pressure and buoys provides warning of secondary tsunami arrivals that threaten the coastline in the minutes-to-hours after the earthquake.
2-3:00 Earthquake Source & Tsunami Modeling Begins
Preliminary data from multiple instruments are synthesized and used to constrain automated, predictive models. This synthesis includes updated information about the event magnitude and location, active deformation of the shelf and slope, and changes in sea surface height.
30:00+ Aftershocks
Large aftershocks occur in the minutes-to-days following the mainshock. Early warnings are issued for subsequent events.
CEV 3-30-17


Commercial Bottom Trawling &
EFH Areas Protected from Fishing
BRITISH COLUMBIA
VANCOUVER
PORT ALBERNI
ABBOTSFORD
VICTORIA
NEAH BAY
SEATTLE
TACOMA
OLYMPIA
PACIFIC BEACH
WASHINGTON
WARRENTON
PORTLAND
PACIFIC CITY
SALEM
OREGON
EUGENE
FLORENCE
BANDON
CALIFORNIA
BROOKINGS
EUREKA
49°
47°
45°
43°
41°
Commercial Bottom Trawling Intensity 2006-2010 -
Areas where high intensity of Commercial Bottom Trawling Fishing activities occur
EFH Areas Protected from Fishing -
National Marine Fisheries Service designated Essential Fish Habitat (EFH) areas where habitat disturbance is prohibited. Fishing activities are allowed if they do not disturb EFH.
700 Fathom Contour Line -
All portions of the cables from the shore to a distance of at least 1km seaward of the 700-fathom line must be buried
GIS support provided by 48 North Solutions, Inc.
0
100km


Existing Cables, Marine Protected Areas, &
National HAPC Rocky Reefs
BRITISH COLUMBIA
VANCOUVER
PORT ALBERNI
ABBOTSFORD
VICTORIA
OCEAN NETWORKS CANADA
NEAH BAY
SEATTLE
TACOMA
OLYMPIA
PACIFIC BEACH
WASHINGTON
WARRENTON
PORTLAND
OOI CABLED NETWORK
PACIFIC CITY
SALEM
OREGON
EUGENE
FLORENCE
BANDON
CALIFORNIA
EUREKA
49°
47°
45°
43°
41°
Existing Cables –
NOAA charted Submarine Cables, 2015.
Marine Protected Areas 2014 –
NOAA charted Marine Sanctuary and Protected Areas (Permitting will require additional consultation with Federal Agencies).
National HAPC Rocky Reefs -
Rock Reefs and Rocky Outcrop areas where 100% of cable burial may not be possible.
700 Fathom Contour Line -
All portions of the cables from the shore to a distance of at least 1km seaward of the 700-fathom line must be buried
48 north solutions
(GIS support)
3-30-17
0
100km

Infrastructure Comparison Chart

	Seismic Monitoring	Geodetic Monitoring	Earthquake Early Warning	Tsunami Early Warning	Supports Other Sensors	Data Latency or Data Rate	General Reliability	Resists Damage During Earthquake	Technology Maturity	Installed Cost Per Node (Initial)	Maintenance Cost Per Node
Cable Designs						*Latency*					
Fixed Cable	●	●	●	●		microseconds to milliseconds	✓✓✓	✓	✓✓✓	$$$	$
Configurable Cable	●	●	●	●	●	microseconds to milliseconds	✓✓✓	✓	✓✓✓	$$$$	$
Hybrid Cable	●	●	●	●	●	microseconds to milliseconds	✓✓✓	✓	✓✓✓	$$$$	$
Buoys & Moorings						*Latency*					
Primary Cell Buoy/Moorings	● (grey)	● (grey)		●	● (grey)	seconds	✓✓	✓✓	✓✓	$$	$$
Hydrokinetic Energy Buoys/Moorings	● (grey)	● (grey)		●	● (grey)	seconds	✓✓	✓✓	✓	$$$	$
Mutihop RF buoys	● (grey)	● (grey)		●	● (grey)	minutes	✓	✓✓	✓	$$	$
Subsea Links						*Rate*					
Wireless Power Transfer					● (grey)	kWatts over centimeters	✓✓	✓	✓✓	$	$
Optical Data Transfer					● (grey)	upto 500 Mbps over meters	✓✓	✓	✓✓	$	$
Acoustic Mesh		●		● (grey)	● (grey)	kbps over kilometers	✓✓	✓✓	✓✓	$	$
Platforms						*Latency*					
Wave Glider		● (grey)		● (grey)		seconds	✓✓	✓✓✓	✓✓	$	$$
Sea Glider/Deep Glider					● (grey)	hours between surfacing	✓✓	✓✓✓	✓✓	$	$$
AUV					● (grey)	hours between docking or surfacing	✓✓	✓✓✓	✓✓	$	$$
Other											

● (grey) Grey dots indicates that the technology could be used in combination with other systems as part of a complete solution

Sensing System Comparison Chart

Sensors	Seismic Monitoring	Geodetic Monitoring	Earthquake Early Warning	Tsunami Early Warning	General Reliability	Resists Damage During Earthquake	Technology Maturity	Installed Cost Per Node (Initial)	Maintenance Cost Per Node
Seismometer	●	● (grey)	●		✓✓✓	✓	✓✓✓	$$	$
Accelerometer	●	● (grey)	●		✓✓✓	✓	✓✓✓	$	$
Tilt Meter	●	● (grey)	● (grey)		✓✓✓	✓	✓✓✓	$	$
Seafloor Pressure	●	● (grey)	● (grey)	● (grey)	✓✓✓	✓	✓✓✓	$	$
Fiber Optics for strain, pressure, temperature	●	●	● (grey)	●	✓✓	✓	✓	$$	$
Remote Sensing	●	●		●	✓✓✓	✓✓✓	✓✓✓	$$$	$
Gravity Meter	●	●			✓✓✓	✓✓✓	✓✓	$	$
Acoustic GPS		●			✓✓	✓	✓✓	$$	$$

● (grey) Grey dots indicates that the technology could be used in combination with other systems as part of a complete solution